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RESEARCH REPORT NO 13

The Medical Effects of Seat Belt Legislation in the United Kingdom

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THE MEDICAL EFFECTS OF SEAT BELT LEGISLATION IN THE UNITED KINGDOM

by

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Foreword

This study and the two related sub-studies are important and timely. They help in understanding the effects which front seat belt wearing have had on the injuries suffered by car occupants. Accidents before and after seat belt legislation in 1983 were included in the study, which will contribute to the knowledge gained by related research and monitoring exercises on road traffic accidents. These include the work of the Department of Transport, the TRRL, the Oxford Road Accident Group and the work of Professors Durbin and Harvey at the London School of Economics, who have conducted an independent assessment of all available statistical evidence of the effects of compulsory seat belt wearing.

This particular work describes changes in injuries amongst patients attending the hospitals which participated in the study. The findings identify possible areas for further research.

The Department is grateful to Mr W H Rutherford for leading this project, to Dr H R M Hayes, Professor Tony Greenfield and Mrs J K Nelson for their hard work in the field and in the analyses and to Dr J P Bull for his most helpful advice throughout.

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1. Abstract

Patients from car accidents arriving at eight hospitals in England, two in Scotland, one in Wales and four in Northern Ireland in the year before and the year after the introduction of the mandatory wearing of seat belts in the front seats of cars in the United Kingdom were compared. The study was designed to supplement the national statistics for dead and injured victims of road traffic accidents by showing the effect of the legislation on patients with injuries of different severities and by establishing the relative frequencies of injuries to specific organs before and after legislation.

The 15 hospitals were selected because it was known that high standards of data collection would be maintained. Though they were not strictly representative, there was a reasonable number of urban, rural and motorway accidents presenting to the different hospitals, and there is no reason to suspect that the patients were atypical of those in the country as a whole.

In order to avoid spurious claims for significant effects created by the volume of available data, prior to the analyses, 17 hypotheses of the expected effects were established based on previous studies. In general, the claims for significant effects were based only on the testing of these hypotheses.

The study revealed a 15% reduction in patients brought to hospital, a 25% reduction in those requiring admission to wards, and a similar fall in bed-occupancy. There were fewer patients with severe injuries after legislation, and the numbers of patients with multiple severe or minor injuries were reduced. The only types of injuries that were definitely reduced in number were abrasions, contusions and wounds of the face and eye and brain and lung injuries. However, this study suggests that kidney injuries and fractures of the femur decreased as well as many minor injuries although these findings are not yet proven. Two injuries have apparently increased: fractures of the sternum and sprained necks.

Over a wide range of injuries both drivers and front seat passengers have derived considerable benefits but the latter enjoyed the greater improvement.

There is a group of injuries to the head (major brain injuries, some facial fractures and other minor scalp injuries) which has increased among drivers possibly due to contact between the driver's head and the steering wheel.

The severity of injuries among the unbelted got worse in the second year. Late night and early morning motorists in this sample wore belts less often and suffered more severe injuries.

The recommendations made on the basis of this study may be found in Section 10.3.

2. Introduction

2.1 How the study arose

On 28th July 1981, the Transport Bill reached the end of its long and somewhat tortuous passage through the Houses of Parliament and became law. In one important respect the Act was different from the Bill as originally prepared and presented by the then Secretary of State for Transport, Mr. Norman Fowler – it contained a clause introducing the mandatory wearing of seat belts, for drivers and front seat passengers in cars.

When the legislation went to the Lords, Lord Nugent moved an amendment which was accepted. In due course the matter came back to the lower chamber, and in the subsequent free vote allowed by the government was accepted.

The way in which this legislation was introduced had two important effects on the subsequent development of the research project. Firstly, the time required for drafting detailed regulations presented an opportunity for a study in which some data could be collected prior to the enforcement of legislation, for comparison with similar data collected after enforcement. Secondly, the measure was to be introduced for a trial period of three years. There was therefore an obligation on the government to set up proper arrangements for monitoring the effects of the legislation, so that good evidence would be available on which a decision could be made either to prolong or rescind the measure.

The importance of rapidly setting up the necessary structures for monitoring the effects was referred to in a letter to the British Medical Journal on 8th August 1981 from Dr J G Avery of the Warwickshire Area Health Authority (See Appendix No 1). He identified Accident and Emergency departments of hospitals as suitable places for collecting information, and suggested that the Department of Health and Social Security, the British Medical Association or one of the Royal Colleges should set up a working party.

This letter was read by one of the authors of this report (WHR). He was impressed by the urgency of the situation. This induced him to proceed immediately with the writing of a protocol for a research project to monitor the medical effects of the legislation. He made a direct approach to the consultants of a number of Accident and Emergency departments to seek their co-operation with a view to approaching the Department of Health and Social Security to obtain the necessary funding.

On 21st August 1981 he wrote to the Department of Health and Social Security in London with an outline proposal. At this stage he also contacted Professor Tony Greenfield at the Department of Medical Computing and Statistics, the Queen's University of Belfast, who agreed to join him in planning and carrying through the research.

By 9th September 1981 a protocol had been prepared for the study which was submitted to colleagues in Accident and Emergency Departments of some 20 hospitals in England, Scotland, Wales and Northern Ireland. Fifteen hospitals agreed to join the study and data from 14 of these were eventually used for analysis. The names of the A & E consultants and the 14 hospitals are given in Appendix 2.

It was originally planned to collect details of injuries and patients from the hospitals and about the accidents from the police. Data collection forms and coding methods were devised. The proposal about collecting information from the police proved impractical and was dropped.

During the early stages of planning enthusiastic support for the project was received from Dr J D J Havard of the British Medical Association, Miss Barbara Sabey of the Transport and Road Research Laboratory, from the Royal Society for the Prevention of Accidents and from the Medical Commission on Accident Prevention. The members who agreed to collect data in different hospitals were all members of the Casualty Surgeons Association, and on 16th October 1981, this body agreed officially to support the study.

The first letters and meetings with the Department of Health and Social Security were considered as informal soundings. On 11th November 1981 the Department suggested that a formal application for a research grant should be made. A meeting at the DHSS to consider this application was held on 21st December 1981 (see Appendix No. 3).

Following this meeting the application was sent to referees. Taking their reports into consideration, the application was finally agreed on 7th April 1982. As the research would cover the whole of the U.K. it was decided that 80% of the expenditure should come from the Department of Health and Social Security for England and Wales, 10% from the Department of Health of the Scottish Office and 10% from the Department of Health and Social Services of the Northern Ireland Office.

When planning the study the best prediction available was that the implementation of the seat belt legislation would come into force about 1st July 1982. It was our objective to have a prospective study which included data for at least six months prior to legislation. We therefore proceeded in November 1981 to print and distribute data collection forms to colleagues in the co-operating hospitals in the hope that the DHSS would eventually sanction the expenses incurred. Some data collection began in December 1981 and by 1st January 1982 all 15 hospitals were collecting data. Eventually the December and January data was considered as a preliminary trial for testing out the system. All tables presented are based on data collected from 1st February 1982.

2.2 The purpose of the study as defined at the outset

The purpose was originally stated as being to establish sound evidence of the changes in hospital casualties among car occupants injured in road traffic accidents consequent on the introduction of compulsory seat belt legislation in the United Kingdom. It was hoped to demonstrate a reduced mortality, a reduction in the severity of injuries, a reduction in some specific injuries (e.g.

head and eyes) and a related reduced need for hospital beds. A possible increase in certain injuries due to the mode of action of the seat belt was anticipated and these would be looked for. We thought that we might be able to suggest some improvements in the type of belt in the light of the resulting injury pattern.

This hospital-based study was seen not as an isolated project, but to be understood within the context of the national road accident statistics, and the in-depth studies of the biomechanics of injury being undertaken by the Transport and Road Research Laboratory of the Department of Transport on selected accidents.

As noted previously, the legislation making seat belt wearing compulsory was to be introduced for a trial period of three years, at the end of which it was to be evaluated to enable a long term decision to be made. For such an evaluation it seemed desirable that the effects of the legislation on specific types of injuries and their severity should be known. Some evidence of the effect of seat belt wearing in the United Kingdom was available, but this related to voluntary wearing by small numbers. It was important to see whether the favourable effects would continue if belt wearing was widespread because of legislative compulsion. For these reasons a study of car occupant patients before and after legislation was thought to be important.

Assessments of the effectiveness of such legislation had been made in other countries. The most thorough data were from Australia. Most of the Australian studies were based on national statistics, and lacked detail about the nature and severity of specific injuries. The study into injury conducted by the Royal Australasian College of Surgeons did produce detailed figures for specific injuries, but this study was only commenced after the legislation was already in force, and these did not contain comparisons with the state of affairs before the legislation.

Part One

PATIENT STUDY

3. Literature Review

3.1 Introduction

The literature in the medical and engineering journals relating to seat belts and in particular their effectiveness can be conveniently divided into four sections with some papers falling into more than one. These divisions are:

(i) papers on the effectiveness of seat belts
(ii) papers on the effect of legislation requiring the use of seat belts
(iii) papers concentrating on the effect of using seat belts on the avoidance or generation of specific injuries
(iv) papers presenting a detailed examination of the mechanical performance of seat belts in accidents.

This brief review will concentrate on papers and reports in the first two groups and will at the same time touch upon those in the third section. The mechanical performance of belts is outside the scope of this study.

It is initially worth examining the difference between the first two groups of papers mentioned above. Those which look at the effectiveness of seat belts generally compare the severity of injuries and the detailed patterns of injuries for the belted and unbelted car occupants. They examine the mortality and morbidity rates for these groups and may be set in either voluntary or mandatory use environments. From them one might speculate on the probable effect of legislation but they do not directly measure its effect.

Papers looking at the effect of seat belt legislation use as the groups for comparison those involved, whether injured or not, before and after the date of its introduction, combining the belted and unbelted in each period. It is into this category that the present study falls and thus it is this subject area which is considered first and the one which is examined in greatest detail.

3.2 The effect of seat belt legislation

Since the introduction of a law requiring front seat occupants of cars to wear seat belts in the state of Victoria, Australia, on 22nd December 1970, many countries have followed suit to greater or lesser extents. The most recent count shows that there are currently 29 countries with such laws.

For many of these countries, there are papers presenting evidence of the changes in the numbers and severities of injured occupants before and after the law, based either on official statistics or special studies, at hospitals for example. These include papers demonstrating the effect in Sweden (1), Denmark (2), France (3), New Zealand (4), the Federal Republic of Germany (5), Canada (6), the Irish Republic (7) and many of the Australian states (8–11). These authors uniformly report a decrease in the number of fatalities seen after the introduction of the law but the size of the decreases presented varies considerably.

Williams and O'Neill (12) consider the reasons why seat belt laws appear to be less effective than predicted. They suggest that limitations of belt use surveys, incorrect belt use and adverse interactions between front and unrestrained rear seat occupants all lead to inaccurate estimates of effectiveness. They support the point made by Hurst (13) that the highest risk groups, the young, the drunk and those driving at night, are least likely to be belted. Indeed the whole question of there being a positive effect of seat belt laws has been questioned by Adams (14) who examined the accident records of a number of countries with and without laws and concluded that it was not possible to isolate the effects of such laws from other factors such as the energy crisis of the mid-1970's. He suggested that the risk compensation theory proposed by Peltzman (15) causes drivers to produce greater risks for other classes of road users when belted. This theory has been examined (16) and has, at least in the Canadian context, been found to be unsupported by direct observations of driver behaviour.

While there are numerous papers examining the effect of legislation on the changes in numbers of fatalities and of injured occupants, a search of the literature reveals very few indeed which present in detail the changes in overall injury patterns with compulsory belt use. Studies of changes in the incidence of specific injuries are reported by various authors and are considered below. A drawback of assessing effectiveness by looking only at the official injury severity classifications is the lack of discrimination resulting from their breadth.

Injuries sustained by fatally injured car occupants have been reported by Cameron and Nelson (17). They used data collected by Hossack (18), supplemented by the findings of Tonge et al (19), mostly from the city of Melbourne as the before sample. The data covering the period after the law were extracted from the Royal Australasian College of Surgeons survey (20) which was conducted throughout the State of Victoria and for various reasons had a rural bias. The differences in sampling conditions necessitate treating the findings with caution. Comparison of the common severe injuries sustained show that many are more prevalent afterwards with increases in the percentages of skull fracture, facial bone fracture, cervical spine and cord injuries, brain damage, chest, lung and heart injuries, damage to the abdominal contents and fractures of most long bones. These apparently anomalous results are partly explainable by the rural bias of the after sample with its likely trend towards higher energy accidents taken with the fact that in the after sample the belt use rate is only 24 per cent (the rate for the before period is not reported).

Three other studies employed similar methods to the present project and thus had the potential for reporting in a similar way. Andreasson and Roos (1) collected data from 16 Swedish hospitals for three corresponding months in 1975 and 1976, either side of the introduction of their law. They note a reduction in attendance of 19 per cent and in admissions of 29 per cent. Unfortunately the remainder of their analysis simply compares the belted and the unbelted.

Nordentoft et al (2) conducted a similar before and after study based on a single hospital at Odense, Denmark. They too noted an 18 per cent fall in casualty attendances but did not discuss injury patterns before and after the law.

The third hospital-based before and after study is reported by Dagnone and Siu (21) and relates to part of Ontario, Canada. Their mixing of different types of seat belts, use of non-standard injury severity measures and mode of presentation of the results relating to injuries renders it impossible to compare their findings with those of other studies, including the present one.

It is interesting to examine the change of incidence of specific injuries coinciding with the introduction of seat belt legislation.

A change in the frequency of head injuries has been reported by Petty (22, 23). In his first paper which looks at two 12 month periods either side of the law in Victoria, he noted a doubling of mild head injury from 37 cases to 74 and a fall from 30 to 12 for severe head injury (he defined mild head injury as normal consciousness regained within one week and no neurological deficit, and severe injury as impaired consciousness or neurological deficit after a week). The second paper added a second "after" year (1976) in which there were only 25 cases of mild head injury and seven severe. Petty cannot explain the peaking of the first "after" year although he does note that other authors reported a similar effect. He does not present seat belt use rates for the three periods but Milne (24) observed that in 1969 usage was about 16 per cent in Victoria and as had already been noted (17) in fatal accidents the rate was only 24 per cent after the law came into force.

The changing pattern of facial bone fractures is the subject of a paper by Afzelius and Rosen from Lund in Southern Sweden (25). While showing no change in the overall number of facial fractures, they note that the number of severe fractures (Le Fort II and III and other combined middle face fractures) is statistically significantly lower after the law than before, the fall being from 36 per cent before 1975 to 12 per cent for 1977–79.

A fall in full-thickness global lacerations of the eye has been reported by Briner (26) from Brisbane. In the six and a half years before legislation he treated an average of 17.7 cases per year whereas in the two and a half years after this figure fell to 9.6. In the 24 cases in the after period, seat belts were only worn by four casualties and Briner comments that for only one of these was it worn correctly. The average loss of visual acuity was 30 per cent for the involved eye.

Trinca and Dooley (27) also note a reduction in eye injuries in adults as the cause of admission to the Royal Melbourne Hospital. Prior to the law it was running at 16 cases a year and after this fell to four cases per annum. A similar fall was not seen for children's eye injuries as they were not at that time covered by compulsory seat belt legislation.

Ryan and Ragazzon (28) and Vellar et al (29) examine abdominal injuries before and after the belt use law in Victoria. In the seven years up to and including 1970, there were 101 cases of abdominal injury compared with 94 in the following seven years according to the former paper. No change in spleen or kidney injuries was seen but liver injuries fell from 26 per cent to 11 per cent, possibly due to the reduction in crushed chests after legislation. Injuries to the gastrointestinal tract and diaphragm rose from 10 to 19 per cent and 1 to 13 per cent respectively. Ryan and Ragazzon postulate that incorrect wearing of the lap section of the belt leads to increased intra-abdominal pressure which causes either the diaphragm to rupture or the liver to be injured, but never both. The series examined by Vellar et al comprises four cases before the law and 11 after in equivalent time periods. They note abdominal bruising and link this causally with abdominal compression and rupture of the upper part of the jejunum. They attribute it, rather strangely, to the sash (shoulder) part of the belt; this may simply be an error of nomenclature. Both papers recognise the need for improved belt systems to prevent abdominal injury.

Burke (30) made a special study of spinal cord injuries in relation to seat belts and reported a decline in the number resulting from motor vehicle crashes following compulsory belt wearing. He also noted a change in the pattern of injuries with relatively fewer injuries to the lumbar spine and fewer complete spinal cord lesions of all kinds.

3.3 The effectiveness of seat belts

As was explained earlier, the effectiveness of seat belts is measured by comparing the belted with the unbelted. What is widely regarded as the first definitive paper on this subject is that of Bohlin (31) in which he studied over 28,700 accidents in Sweden involving 2,445 injured occupants. He concluded that the three-point seat belt reduced the frequency of injury of all kinds substantially and the frequency of certain injuries (particularly to the head and upper torso) very substantially, offered effective protection against ejection and did not cause serious injury to the wearer. He estimated that the injury reducing effect varied between 40 and 90 per cent depending on the speed and accident type.

The only other study of comparable size is that of Nelson (20). Injury details on 23,000 car occupants were collected over a two year period following the introduction of compulsory seat belt use in the State of Victoria. The findings of this very extensive study are numerous. The most common severe injuries sustained were fractures of the skull, with or without intracranial damage, severe primary brain damage, fractures of the facial bones, chest wall and femur, lung, aorta, spleen and liver injuries. With the exception of ruptured spleen and fractured femur, all of these injuries were significantly more likely to occur in unbelted casualties. Amongst unbelted fatalities Nelson reports that fractures of the skull, with and without intracranial injury, and aortic rupture were also significantly more common. Some severe injuries were found to be significantly more common among belt wearers (at the 10 per cent level of confidence). These were whiplash (present in 3.9 per cent of seriously injured belted casualties and 2.6 per cent of unbelted), and transient spinal cord damage (present in less than 0.5 per cent of both groups). Other conclusions included differences between urban and rural crashes, different injury patterns for different crash configurations and some age dependence in injury patterns. The main features of this report are summarised elsewhere (17.32).

Two British papers looked at the differences between belted and unbelted occupants in the voluntary use environment. Christian (33) analysed a series of 969 drivers and front-seat passengers attending one hospital, 20 per cent were belted. She found that there was little difference between the nature and severity of leg injuries for the belted and unbelted although there were fewer fractures among the belted. Soft tissue chest injuries occurred almost twice as often among the belted but multiple rib fractures and the associated severe intrathoracic injuries were more common for unbelted occupants. Clavicle fractures were seen much more often in seat belt wearers, generally on the side crossed by the belt. Spinal injuries, although rare, were found three times more often in the unbelted. Fractures of the skull and facial bones and soft tissue facial and scalp injuries were associated with non-use of the belt. Neck sprains and external abdominal bruising were both more often seen among belt wearers but internal abdominal damage happened in only half as many belted as unbelted casualties. Eye injuries were entirely confined to people not wearing seat belts.

Hobbs (34) reporting on over 2,400 car occupants in crashes studied in depth showed that half of the non-minor injuries were prevented by belt use. The head was the most commonly injured body area for all occupants. Belted drivers were found to suffer more severe head injuries than belted passengers but the difference was not statistically significant.

There are many other papers on car occupant protection which will not be considered in this review. There is a unified view from investigators around the world that seat belts, while causing some relatively minor injuries, are an important means of protecting car occupants in crashes. The present study reaches a similar conclusion but it also fills a gap in the literature by presenting a comprehensive before and after study based on high quality medical data demonstrating the change in injury patterns associated with seat belt use legislation.

References

3.4 References

(1) ANDREASSON R, and ROOS K. Effects of Sweden's seat-belt law. Proceedings of 6th International Conference of the Association for Accident and Traffic Medicine, Melbourne, 1977.

(2) NORDENTOFT E L, NIELSEN H V, ERIKSEN W and WEETH R. Effect of mandatory seat belt legislation in Denmark with special regard to minor and moderate injury. Proceedings of 6th International Conference of the Association for Accident and Traffic Medicine, Melbourne, 1977.

(3) CHODKIEWICZ J P, and DUBARRY B. Effects of mandatory seat belt legislation in France. Proceedings of 6th International Conference of the Association for Accident and Traffic Medicine, Melbourne, 1977.

(4) TOOMATH J B. Compulsory seat belt legislation in New Zealand. Proceedings of the 6th International Conference of the Association for Accident and Traffic Medicine, Melbourne, 1977.

(5) SEIDENSTECHER K. Laws on mandatory seat belt use and their enforcement in the Federal Republic of Germany. Proceedings of the International Symposium on Occupant Restraint, Toronto, A.A.A.M., Morton Grove, Ill., 1981.

(6) SIMPSON H A, and WARREN R A. Seat belts and traffic safety: the Canadian experience. Proceedings of the International Symposium on Occupant Restraint, Toronto, A.A.A.M., Morton Grove, Ill., 1981.

(7) HEARNE R. The initial impact of the safety-belt legislation in Ireland. An Foras Forbartha, Dublin 1981.

(8) VAUGHAN R G. Seat belts – some aspects of compulsory wearing in New South Wales, Australia. Proc. Instn. Mech. Engrs., Vol. 191, 3/77, 31–37, 1977.

(9) McDERMOTT F, and HOUGH D. Vehicle-occupant fatalities after legislation for compulsory wearing of seat belts in Australia. Med. J. Aust., 2, 571–5, 1979.

(10) FOLDVARY L A, and LANE J C. The effectiveness of compulsory wearing of seat belts in casualty reduction. Accid. Anal. & Prev., 6, 59–81, 1974.

(11) JAMIESON K G, and KELLY D. Traffic injuries in Brisbane hospitals over one decade. Aust. N.Z. J. Surg. 44/2, 150–157, 1974.

(12) WILLIAMS A F, and O'NEILL B. Seat belt laws: implications for occupant protection. Passenger Car Meeting, Dearbora. Paper No. 790683, S.A.E., Warrendale, Pa., 1979.

(13) HURST P M. Compulsory seat belt use: further inferences. Accid. Anal. & Prev., 11, 27–33, 1979.

(14) ADAMS J G U. The efficacy of seat belt legislation. Paper No. 820819, S.A.E., Warrendale, Pa., 1982.

(15) PELTZMAN S. The effects of automobile safety regulation. J. Political Economy, 83, 677–725, 1975.

(16) LUND A K, and ZADOR P. Mandatory belt use and driver risk taking. Risk Analysis, 1984.

(17) CAMERON M H, and NELSON P G. Proc. 6th International Conference of the International Association for Accident and Traffic Medicine, Melbourne, 1977.

(18) HOSSACK D W. The pattern of injuries received by 500 drivers and passengers killed in road accidents. Med. J. Aust., 2, 193–195, 1972.

(19) TONGE J I, O'REILLY M J J, DAVISON A, and DERRICK E H. Fatal traffic accidents in Brisbane from 1935 to 1964. Med. J. Aust., Nov. 1964.

(20) NELSON P G. Pattern of injury survey of automobile accidents, Victoria, Australia, June 1971 – June 1973. Royal Australasian College of Surgeons, Melbourne 1974.

(21) DAGONE L E, and SIU T O. Restraint system utilization and its consequences among victims of motor vehicle collisions in South-eastern Ontario, SB–79–06. Ministry of Transportation and Communications, Downsview, 1979.

(22) PETTY P G. The influence of seat belt wearing on the incidence of severe head injury. Med. J. Aust., 2, 768–769, 1975.

(23) PETTY P G. The influence of seat belt wearing on the incidence of severe head injury. Proc. 6th International Conference of the International Association for Accident and Traffic Medicine, Melbourne, 1977.

(24) MILNE P W. Fitting and wearing of seat belts in Australia: the history of a successful countermeasure. Australian Government Publishing Service, Canberra 1979.

(25) AFZELIUS L E, and ROSEN C. Influence of seat belt upon maxillofacial fractures. ORL J. Otorhinolaryngol. Relat. Spec., 42, 277–281, 1980.

(26) BRINER A M. Penetrating eye injuries associated with motor vehicle accidents. Med. J. Aust., 1, 912–914, 1976.

(27) TRINCA G W, and DOOLEY B J. The effects of seat belt legislation on road traffic injuries. Aust. N.Z. J. Surg., 47, 2, 150–155, 1977.

(28) RYAN P, and RAGAZZON R. Abdominal injuries in survivors of road trauma before and since seat belt legislation in Victoria. Aust. N.Z. J. Surg., 49, 2, 200–202, 1979.

(29) VELLAR I D, VELLAR D J, and MULLANY C J. Rupture of the bowel due to road trauma: the emergence of the "seat belt syndrome". Med. J. Aust., 1, 694–696, 1976.

(30) BURKE D C. Spinal cord injuries and seat belts. Med. J. Aust., 2, 801–805, 1973.

(31) BOHLIN N I. A statistical analysis of 28,000 accident cases with emphasis on occupant restraint value. Proc. 11th Stapp Car Crash Conf., Paper No. 670925, S.A.E., 1967.

(32) NELSON P G. Aspects of injury patterns in automobile accidents. Aust. N.Z. J. Surg., 47, 2, 162–165, 1977.

(33) CHRISTIAN M S. Non-fatal injuries sustained by seat belt wearers: a comparative study. B.M.J., 2, 1310–1311, 1976.
(34) HOBBS C A. The effectiveness of seat belts in reducing injuries to car occupants. TRRL Laboratory Report 811, Transport and Road Research Laboratory, Crowthorne, 1978.

4. Methodology

4.1. Introduction

In this chapter, the selection of the hospitals for participation is discussed briefly. The criteria for the inclusion of a case are considered in detail. The data collected at each hospital and those added when the collection forms reached the project headquarters are presented together with the different methods used by each hospital to acquire the data. An important aspect of the data acquisition and the maintenance of their quality was a regular programme of visits to the hospitals. This regime and the reason for it are described in detail. Finally the coding and checking procedures are outlined.

4.2 The selection of the study hospitals

As this study was intended to provide definitive answers to questions relating to the effect on injuries of the introduction of the law requiring the wearing of seat belts in cars, it was essential that the size of the data bank established during the study should be as large as was practically possible within the manpower and resource limitations of the project. To achieve this, one of the authors (WHR) approached the Consultants-in-Charge of the Accident and Emergency Departments of 20 hospitals throughout the United Kingdom seeking their co-operation and assistance in a prolonged project. It was understood from the outset that their involvement would be on a voluntary basis and that no staff could be provided to the hospitals to assist with the data collection or extraction. Fifteen hospitals agreed to participate. A major change in staffing arrangements in one of these resulted in marked changes in the capturing of data in the middle of the second year. For this reason all its data were regretfully eliminated. The names of the 14 remaining hospitals whose patients and their injuries form the basis of this report are given in Table 1.

In a project such as this in which data collection was to extend over two years and where the numbers of relevant cases were relatively high, as shown in Table 1, it was particularly important that the staff of those hospitals invited to be involved were known to be interested in the subject and would remain committed to their participation for the duration of the study. It is recognised that such a basis for selection may not be scientifically rigorous in that it may not generate a sample of accidents which can be regarded as nationally representative. It is nevertheless a most important factor in maintaining the quality and supply of the data. The question of the representativeness of the data is discussed elsewhere in this report (see Section 6.1, 8.18 and 8.19).

It can be seen from Table 1 that the study hospitals were spread throughout the United Kingdom with three in Northern Ireland, two in Scotland, one in

Wales and eight in England. Their catchment areas included urban and rural roads and motorways.

4.3 Case selection criteria

The principal unit of data in this study was the casualty (as opposed to the vehicle or accident). For a person to be included in the study, he or she had to meet all of the following conditions:

(i) involvement in an accident involving a motor vehicle on the public highway between 1st February 1982 and 31st January 1984.

(ii) being an occupant of a vehicle which was affected or from 31st January 1983 would be affected by the seat belt wearing law, i.e. a vehicle in which the Construction and Use Regulations required the compulsory fitting of seat belts in the outboard front seating positions. Basically this meant cars and vans up to about three tons unladen weight. Similar vehicles registered before 1st January 1965 which do not require seat belts to be fitted were also included.

(iii) attendance and registration at the Accident and Emergency Department of one of the study hospitals.

No arrangements were made to document cases given medical exemption from wearing seat belts, and we are not aware of any such patients.

Patients who were transferred from other hospitals to the study hospitals for specialist treatment were excluded. In practice it was quite simple to identify these cases as in most hospitals they by-pass the normal A & E Department registration systems.

It may be noticed that some of those who presented at hospital were found on examination not to have sustained any injury. The reason for the exclusion of the uninjured from the bulk of the analyses in this report is explained later.

Steps were taken during the course of the data collection period to ensure that there were no variations in local case acceptance procedures at the hospitals which could influence this project. Changes in catchment areas or the opening or closure of nearby hospitals could have affected the overall case throughout. Similarly, a change of policy to accept a particular group of patients who had previously been taken elsewhere, such as children or burn victims, could have produced distortions. No such changes were detected.

There were slight differences between hospitals in that while most accepted all casualties from within fairly closely defined catchment areas and conversely all casualties in those areas went to specific hospitals, in three situations this was not so. The exceptions were:

(a) in the catchment area of one study hospital, children were taken to the local children's hospital.

(b) in certain circumstances, serious burn victims would not go to a study hospital from accidents within its normal catchment area but would be transported to a nearby burns unit.

(c) the catchment area of one study hospital was much larger for very seriously injured patients than it was for patients as a whole.

The distortions produced by these practices are small in the context of the study as a whole and thus do not seriously compromise the results, especially as the conditions remained the same in the periods before and after the introduction of the law.

4.4 The data collected

Using the main data collection form which is described in the next section, 22 data items were recorded for each person registered at a study hospital. Of these, 18 were normally entered on the form at the hospital with the remainder completed by the coding clerk at the project headquarters. The data items collected were:

(a) hospital code — a single letter to indicate the relevant hospital

(b) patient registration number — the hospitals' identifying code for that patient enabling the patient's record to be referred back to in the event of a query

(c) patient age

(d) patient sex

(e) date of accident — day, month and year

(f) time of accident — recorded on the 24 hour clock

(g) date of arrival at hospital

(h) time of arrival at hospital

(i) patient's seating position in car — driver, front passenger or rear passenger

(j) injuries — entered in text at the hospital for coding later (Coding system is described below)

(k) condition on arrival — alive or dead

(l) admission detail — whether or not patient was admitted to a ward

(m) detail of death — whether or not patient died in the hospital

(n) date of discharge/death — recorded only for admitted patients

(o) length of in-patient stay — recorded only for admitted patients

(p) seat belt use

(q) doctor's confidence in answer to seat belt use question

(r) seat belt use and injury status of other occupants of same vehicle — this was entered whenever possible. There were considerable inter-hospital differences in its availability and so no analysis was made using this data in Part I of the report.

The four data items entered when the forms reached the project headquarters were:

(s) delay between accident and arrival at hospital

(t) accident number

(u) vehicle number — number assigned to vehicle within that accident

(v) patient number — number assigned to patient within that vehicle

Only two of the data items were in addition to those normally available somewhere in the hospitals' medical records, these being the seating position and seat belt use, and even these were routinely noted in patient histories at some of the hospitals.

The data were collected using two forms. One was designed to be used as a patient interview form (Form 1) in particular for the collection of the seat belt use and seating position information, the other larger form being the main data recording form. Both forms are shown in Appendices 4 and 5. The main data form was not intended to be used in the patient's presence but was to be completed from existing records and from Form 1. The variation in hospital practices for obtaining the necessary data is discussed in the next section.

It can be seen that the main form comprises white boxes and grey boxes. In general, the white boxes were intended for completion at the hospitals and the grey boxes by the project staff either at the project headquarters or at the hospitals. The final question on the main form on blood alcohol level was not used owing to problems with its consistent collection. Also the space on the final page of the main form for affixing Form 1 was a throw-back to the first design of Form 1, superseded early in the data collection period.

4.5 Data acquisition procedures

As has already been noted, only two data items, seat belt usage and seating position, were to be recorded in this study over and above those normally collected under the standard procedures of most hospitals. Indeed, the RTA billing system under which road accident casualties attending any N.H.S. hospital in the U.K. will generate a bill for the driver of the involved vehicle necessitates hospitals identifying drivers as opposed to passengers.

The idealised data acquisition procedure consisted of the A & E Department reception staff identifying casualties from relevant types of vehicles and attaching a copy of Form 1 to the casualties record cards. The doctor examining the patients would then ask where they were sitting, whether or not they were wearing a seat belt and what the seating positions, seat belt usage and injury status of all other occupants of that vehicle were. Form 1 would remain with the record card to be extracted later when all relevant cases were collected together so that the main data collection forms could be completed. In some hospitals this procedure was employed but for various reasons Form 1 was not used universally.

In some hospitals the routine documentation of patients had always included details of seat belt use and seating position (in cases where the patient was a road traffic casualty). This was especially likely where computerised data handling was used.

Elsewhere, there were standing instructions that these data should always be included in the patient histories. In two hospitals, the receptionist would stamp the relevant casualty cards with the questions to be asked of the patients.

These alternative procedures allowed the seat belt and seating position data to be gathered in most cases but usually resulted in the loss of information on other occupants. Clearly the loss was greater for the uninjured as other injured occupants would generate the data in their own right.

The main collection forms were normally completed by one or two people at each hospital. This ensured as far as possible that data quality was maintained. The most complex aspect of their completion was the transfer of the injury details and this was most frequently done by the consultant or senior registrar, with the administrative data often being filled in by a secretary.

4.6 Method of coding injuries

The central two pages of the main data collection form had sections for each of the anatomical regions as set out in the Abbreviated Injury Scale (1980 edition), with the exception that the region "Extremities" was separated into four subregions for left and right and for upper and lower extremities. This gave a total of 10 regions or subregions.

For each of these there were three lines of boxes with three boxes in each line, and these nine had a single tenth box sitting on top. Each three box line was for the coding of a single injury. The first designated the type of injury, A for abrasion, F for fracture, W for wound etc. The complete list is given in Appendix 6. The second box was an anatomical subdivision of the region or subregion, so that in the anatomical subregions for upper extremity 1 stood for thumb, 2 for index, 3 for middle finger etc. The full list of anatomical subsections for each region or subregion is given in Appendix 7. The third box in the line was for the Abbreviated Injury Scale code, as directed in the 1980 edition of the booklet (1).

The single top box was to indicate the total number of injuries in the region or subregion. Where there were from zero to three injuries encoded in the other nine boxes, this merely repeated what was already to be seen. When there were four to eight injuries, the three most severe were fully encoded as explained above, but the top box indicated the total number of injuries, classified or unclassified. Nine in the top box indicated either nine or more than nine injuries.

4.7 Data checking procedures

There were three aspects of the data checking procedures: some checks were done at the study hospitals by one of the authors (HRMH); the forms were checked again by JKN after the injuries had been coded; the final and most rigorous check was made by the computer.

A regular series of visits to all of the hospitals on the UK mainland was instituted for three reasons: to maintain the quality of the data, its constancy of flow and the general interest of the staff. Also, casualties from the same vehicle and accident were linked if this had been done by the hospital.

Each of the hospitals was visited 16 times on average during the two years of data collection, in other words approximately every six weeks. The Belfast hospitals were also visited a few times but it was felt that their proximity and close contact with the project centre did not necessitate frequent visits.

During these routine visits, every completed form was scrutinised so as to minimise problems for the coding clerk. As far as possible, inter-hospital differences in injury descriptions were reduced particularly to allow uniform coding of their severity. Consistency between the patients' disposal, their length of in-patient stay and their injuries was checked and anomalies were regularly questioned. Also, casualties from the same vehicle and accident were linked if this was not done by the hospital.

After a hospital had been visited and its forms checked, they were sent to the project headquarters in Belfast. Here the injury information was coded and all the forms were visually checked before the data were punched onto standard 80/column computer cards. these were then verified and put into the ICL 2900 series computer at the Queen's University of Belfast.

Approximately every six months a computer programme was used to detect any remaining coding or punching errors, for example:

(a) the range of all data items was checked both individually and where possible with other data items. The latter was particularly useful in checking for incorrect injury codes.

(b) the number of injuries coded in each region was checked against the total number of injuries for that region.

(c) the ISS score was computed and checked against the coded value.

Any queries were referred back to HRMH to be resolved on his next visit to the appropriate hospital.

4.8 Other aspects of the methodology

Three points are worthy of note. Firstly, it should be mentioned that before the main phase of the data collection began, the experimental design and the forms had been piloted in all of the hospitals. This resulted in a modification of procedures with a consequential change in the paperwork. Secondly, the six-monthly computer checks were accompanied by some interim analyses which allowed us to monitor the progress of the study.

Thirdly, the further purposes of the regular visits should be explained. Initially, it was important to ensure that the personnel in each hospital had a clear understanding of what was required and that their systems were such that all relevant facts could be identified. Also, there was a need for local practices on such matters as the regular availability of data on casualties who were dead on arrival at the hospital to be discussed so that decisions could be taken on whether or not to include them in the sample. During the first visit a profile of the hospital's catchment area was also established.

Apart from the data checking, other tasks were undertaken during the visits. The most important was a public relations role of keeping all concerned in constant touch with developments in the study and in the wider subject of vehicle safety simply to maintain their interest and to prevent them from feeling like a remote outpost simply passing data to Belfast with no feedback. The other purposes of the visits included seeking for any changes in local policy which could have influenced results (such as a change in the criteria for deciding whether or not to admit patients with suspected intracranial injuries) and generally answering queries which had arisen locally.

It was realised that while it was important to keep staff in touch, care had to be taken so as not to influence a local habit in a way which might affect the quality or quantity of their data. Of prime importance was the need for consistency in all matters throughout the two years of data collection, with problems having been eliminated at the outset.

4.9 Abbreviated injury scale (AIS), maximum abbreviated injury scale (MAIS) and injury severity score (ISS) – explanatory note.

Repeated use is made of these scales and scores throughout the report, and for those not familiar with the system a short explanation may be helpful. The Abbreviated Injury Scale is a system of classifying injuries where the most trivial is given a scale of 1 and the most severe normally encountered a scale of 5. For short these are written as AIS1 and AIS5. There are of course intermediate grades (AIS2, AIS3, AIS4) and injuries like decapitation which are incompatible with life are graded AIS6. A small classification booklet is published by the American Association of Automotive Medicine, and this sets out the rules which govern the exact grading of any injury.

The Maximum Abbreviated Injury Scale (MAIS) is a simple rough guide to overall severity. It is obvious that a patient with a MAIS5 is going to be in a more critical condition than one with MAIS1. However, a patient with 20 AIS1 injuries has an MAIS1, and might well be more ill than a patient with one AIS2 injury (MAIS2). Similarly a patient with four AIS4 injuries (MAIS4) will probably be more ill than one with a single AIS5 injury (MAIS5).

In order to form a more accurate method of indicating total severity from combinations of different numbers of injuries of different degrees of severity a score is calculated called the Injury Severity Score (ISS). This was devised by Susan Baker and her colleagues (2).

In this system the body is divided into six regions: external (i.e. skin and subcutaneous tissues), head and neck, face, thorax, abdominal and pelvic contents and extremities (including pelvic girdle). The injuries within each region are graded according to the Abbreviated Injury Scale (AIS). The three worst injured regions and the worst injury within each are selected, the AIS grades are squared and added together.

By this system a person with an abrasion on the face (AIS1) and no other injuries will have an Injury Severity Score of 1 (ISS 1). A patient with a lacerated brain, a ruptured aorta and ruptured liver, (all AIS 5, and all in different regions) will have ISS 75. Should the patient have an injury incompatible with life (AIS 6), an ISS of 75 is allotted without further calculation. By the use of the Injury Severity Score a single score between 1 and 75 is allotted no matter what the variety of the distribution of varying severities of individual injuries. In the ISS the concept of severity is linked with mortality or survival and not with other effects of injuries which might be thought to be severe, such as blindness or continuing pain. ISS scores have been found to correlate well with mortality when used for grading the severity of road traffic accidents.

4.10 Subsequent developments in the study

We had hoped that hospitals would be able to collect details about those who had already died before reaching hospital. This proved impossible in practice. We decided to use our methodology for a small parallel study of such deaths collected directly from coroners. This study is reported in Part II, Chapter Eleven.

Finally one of the injuries which appeared to increase in incidence in the second year was a sprain of the neck. In considering our figures we wondered if they concealed considerable under-reporting because patients with minor injuries were not aware of their neck pain until after their discharge from hospital. Also patients with major injuries might in the early stages consider their neck pain as too trivial to mention. Nonetheless it might later cause prolonged suffering and much more incapacitating than anything developing from their major injuries. We decided to do a small pilot study in one hospital to test these suspicions. This study is to be reported separately (3).

4.11 References

(1) American Association of Automotive Medicine, The Abbreviated Injury Scale, 1980 Revision. AAAM, Morton Grove, Illinois, 1980.

(2) BAKER S P, O'NEILL B, HADDON W Jr, and LONG W B. The Injury Severity Score: a method for describing patients with multiple injuries and evaluating emergency care. J. Trauma, 14, 187–196, 1974.

(3) RUTHERFORD W H, DEANS G T, and MAGALLIARD J N. The frequency of neck pain among patients in car accidents, and the length of disability. (in press).

5. General Introduction to Analysis

5.1 The unreliability of comparisons from incomplete data

In this project, data were collected for a year before and a year after legislation. It was an investigation directly into the effect of that legislation and only indirectly into the effect of the seat belts. It is very important to remember that our information is limited to those people who sustained injuries. In a study by Bohlin (1) based on car impacts where the evidence was drawn from car insurance statistics, only about six per cent of car occupants in road accidents involving cars sustained any injuries. In such a study, where the facts concerning all the injured and uninjured victims of all such accidents are known, probabilities of injury can be calculated, and the effects of being belted or unbelted in different seating positions estimated. In our own study where we were without information about uninjured car occupants, direct comparisons of groups such as belted patients in the first and second years are likely to be misleading. In the second year many people would have been injured were it not for the positive effect of the belt. Some of the patients who were alive on arrival at hospital may only have survived because of their belts. Increased use of belts in the second year would in this way distort the figures. Great caution must be exercised in interpreting differences between casualties in the two years as well as between belted and unbelted patients.

5.2 The context of traffic volume

Another reason for such caution is the possibility that other factors have been operating to increase or decrease the casualties. The most obvious of these is the traffic load. In New Zealand compulsory seat belt wearing was introduced at a time of rapid traffic expansion. Petrol consumption increased by 12 per cent. As well as this, when the wearing of seat belts was made compulsory, strict speed limits were introduced in the same legislation. Toomath (2) found that there was great difficulty in interpreting the accident statistics and evaluating the effect of each of these factors.

The recent trend in traffic volume in the United Kingdom can be seen in Table No. 2. From 1980 to 1983 each year traffic has increased. The yearly totals of those killed and seriously injured in cars and taxis for 1980, 81 and 82 are given. Using first and second differences it was predicted that had there been no seat belt legislation, the number of casualties in 1983 would have been 34,321. Using the known traffic volume in 1983, an index of casualties per 1,000 million kilometers traffic was calculated (156.0). This appears to conform well with the gradual fall which had been occurring in this index over several years.

Two more indications of traffic volume are the number of registered cars and the national consumption of petrol. In 1982 there were 20,147,000 motor vehicles registered in the UK and in 1983, 20,693,000 — an increase of 2.7 per cent (see Table 3). The national deliveries of motor spirit in 1982 were 18,453 thousand tonnes and in 1983, 21,108 thousand tonnes, an increase of 9.0 per cent (see Table 4.).

All these indicators suggest that there has been a small increase of traffic in 1983 compared with 1982, and without the seat belt legislation we would have expected at least as many casualties in 1983 as in 1982. The first and second years of our study ran from 1st February to 31st January and not from 1st January to 31st December as the statistics for road use and motor spirit deliveries do. The discrepancy is small and we may treat both periods as if they were identical. As far as the context of traffic goes there appears to have been an increase which is probably between two per cent and nine per cent. Accidents and casualties do not rise and fall in direct proportion to traffic volume. However, without legislation, one would have expected some increase which would probably be roughly of this order.

5.3 Other factors which might have been expected to affect traffic accidents during the period of study

5.3.1 The recession

The United Kingdom is in an economic recession, and people may have less money to drive cars. In the second year we would have expected the number of registered cars and the consumption of motor spirit to drop. As seen above, the evidence is that registered cars and motor spirit deliveries increased in 1983. Thus there seems to be no recession effect.

5.3.2 Weather

We have examined only three aspects — fog, frost and snow. Our analysis is based on monthly weather summaries supplied by the Meteorological Office in London for 29 weather stations in the United Kingdom. We analysed results from the 18 stations from which there were figures available for all 12 months of each year from 1st February 1982 — 31st January 1983, and from 1st February 1983 — 31st January 1984. Asking the question "Is there any difference in the number of days when fog was experienced in the two years?", we found that there was no significant change ($P>0.1$). Asking the same question for first (ice) the answer is that the second year was significantly worse ($P<0.001$). Asking the question for snow, the weather is again worse in the second year ($P<0.001$). The details are given in Appendix 8.

5.3.3 Drink and Driving

The other measure in the 1981 Transport Act which might have led to improvement was the clause which sought to remedy deficiencies in laws which aimed at the control of drunken driving. These measures may have had some effect. They were brought into operation on 1st May 1983.

There are two reasons for believing that this did not account for a large proportion of the change in statistics. Firstly this change was made in Great

Britain only. The laws in Northern Ireland had already been amended several years earlier. They did not suffer from the same defects as the law in Great Britain. During the period under review, no change was made in laws in Northern Ireland relating to drinking and driving, nor was there any policy change in enforcement by the police. The changes in casualties in the second year for Northern Ireland, mirror closely the changes in great Britain (see Tables 61-67). Hence it seems difficult to attribute any large proportion of the improvement in Great Britain to the drinking and driving clauses. Secondly it will become evident that in factor after factor, differences can be seen between effects on drivers, front seat passengers and back seat passengers. These variations associated with seating position are easily explained on the basis of seat belt wearing. It is difficult to see how they can be explained on the basis of controlling drunken driving. Better control of drunken driving should affect especially the severe accidents and all seating positions for these accidents. Other arguments in chapter nine (statistical analysis) support our belief that the use of belts was the major cause for the reduction of casualties.

5.4 Comparing first and second year figures on a par

The previous two sections have shown that the weather may have been worse, and the traffic appears to have increased somewhere between 2% and 9%. However, if in the first place we compare the first and second year tables on a par, that is to say on the basis that without legislation one would have expected exactly similar numbers and types of casualties and injuries in the second year as the first, then one is inserting a bias against finding effects which might result from increased wearing of seat belts. This should have the effect of eliminating many small apparent effects, which may have been artefacts. If in our primary inspection of the tables we restrict ourselves to items where the numbers are in reasonable quantity and where the degree of change is sufficiently marked, then we are more likely to avoid wrong inferences and exaggerated claims for the efficiency of seat belt wearing.

5.5 Should we compare patients with patients or injuries with injuries?

A major feature of this study is that it specifies exact injuries and indicates their severity. It is possible to construct tables which compare either injuries or patients. As one patient may have several injuries it may seem that comparing injuries without taking into account the reduction in patients would be erroneous. However, there is no evidence that fewer people are travelling or that they are travelling shorter distances. In fact the trend is upwards. We presume therefore that there have been approximately as many collisions and other road accidents. The postulated effect of the belt is to prevent injury. If there are fewer patients, the most likely reason is because injuries have been prevented. It is therefore logically correct to compare both patients with patients and injuries with injuries in the first and second years.

5.6 The desirability of proceeding on the basis of previously stated hypotheses

For each of the 14,019 patients in this study there were 70 primary items of information. Some of these (like the diagnosis and abbreviated injury scale code) were subject to a further threefold analysis. The number of ways in which this information might be arranged is so large as to burden the imagination. In such a situation every now and then unusual distributions are bound to arise by chance. If subjected to ordinary statistical tests, it may sometimes happen that these random maldistributions would be "proved" to be statistically significant.

To avoid this pitfall, prior to analysis we examined previous literature, and on this foundation set out a number of hypotheses which we considered should be tested. For this purpose the previous studies which appeared to be most useful from our point of view were by H M Cameron and P G Nelson (3) and by P G Nelson (4). From these a number of hypotheses were constructed. These were stated as follows:

The introduction of legislation for the mandatory wearing of seat belts in the front seats of cars should have the following effects:—

(1) A reduction in the number of patients — outpatients, inpatients and deaths.

(2) A reduction in the number of bed days from such patients.

(3) A reduction in the average severity of injuries.

(4) A reduction in the number of severe injuries.

(5) A reduction in the multiplicity of injuries for both major and minor injuries to front seat occupants.

(6) A low probability of death if injured.

(7) A reduction in brain injuries.

(8) A reduction in skull fractures.

(9) A reduction in minor injuries to the face.

(10) A reduction in face fractures.

(11) A reduction in injuries to the lungs.

(12) An increase in sprained necks.

(13) An increase in fractures of the sternum.

(14) Back seat passengers should not benefit to the same extent or follow the same pattern as those in the front seat.

In discussing some of the possible changes between the first and second years, we thought that those who were voluntarily using seat belts in the first year might be the most responsible drivers and their careful driving might result in less severe injuries, giving an appearance of exaggerated effectiveness to their seat belts. Similarly in the second year those who refused to wear seat belts might be irresponsible and reckless drivers, thus giving the appearance of a more deleterious effect of non-belt-wearing than was justified.

We also felt that late night/early morning drivers would tend to wear their belts less and possibly to drive more recklessly. From this speculation we constructed the following hypotheses:

(15) Front seat occupants who are belted will have lower mean severity scores in the first year than the second.

(16) Front seat occupants who are unbelted in the second year will have higher mean severity scores than in the first.

(17) Late night and early morning front seat occupants will have lower rates of belt wearing and higher mean severity scores than at other times of the day.

In the chapter devoted to statistical analysis the exact wording of these hypotheses has been altered somewhat to enable clearer tests to be performed (see Chapter 9). However, the central meaning of each hypothesis has been maintained.

In the next three chapters in commenting on the results, we will firstly point out those differences which immediately appear interesting or important. If the matter in question is one which is the subject of one of our previously stated hypotheses this will be pointed out, and the results of statistical testing given. Other effects which were not predicted may be the subject of speculative comment. Where the change was very large, we tested it statistically. We do not claim significance for those factors which reach P values which are normally considered as significant, but suggest that they should become the basis of new hypotheses for further studies in this field.

The detailed statistical testing and argument will be collected together in a single chapter (Chapter 9). Here the evidence for and against each hypothesis will be mathematically tested, and the probability that such a result could have arisen by chance will be shown. It is inescapable that the language has to be somewhat technical. For those who do not wish to follow through this statistical argument, all the conclusions are more simply stated in the main body of the report, and cross references given.

5.7 Types of belt in use at the time of assessment

The seat belt which is obligatory under the 1981 Transport Act is a lap diagonal belt. During the period of the study, there were two types of lap diagonal belt in use — the static and the inertia reel. We have no information about which of these types of belt was used by any specific patient. We attempted to find out the proportions of each type in use in the community. There are no official figures but the best unofficial estimate available to us was that over 80% of belts were of the inertia reel type.

5.8 References

(1) BOHLIN N I. A statistical analysis of 28,000 accident cases with emphasis on occupant restraint value. Proc. 11th Strapp Car Crash Conf., Paper No. 670925, SAE 1967.

(2) TOOMATH J B. Compulsory seat belt legislation in New Zealand. Proceedings of the 6th International Conference of the Association for Accident and Traffic Medicine, Melbourne 1977.

(3) CAMERON H M and NELSON P G. Injury patterns with or without seat belts. Proceedings of International Conference of the Association for Accident and Traffic Medicine, Melbourne 1977.

(4) NELSON P G. Patterns of Injury Survey of Automobile Accidents, Victoria, Australia, June 71 — June 73. Royal Australasian College of Surgeons Road Trauma Committee, Melbourne 1974.

6. Patients

6.1 Figures for each hospital and grand total

Table 1 sets out the hospitals which took part in the study, and the total numbers of patients received from car-occupant road traffic accidents in the two years under study. The numbers of accidents and vehicles included in the sample are given in Table 5. As explained in the methodology section, the hospitals were not randomly selected. The geographical spread is somewhat biased towards the north and west. However, both urban and rural situations are well represented, and while not truly representative there is no reason to believe that the hospitals are atypical.

The change in the number of patients seen in the first and second years varied widely between hospital and hospital from –45.5% in the General Infirmary in Leeds to +11.3% at Pinderfields Hospital, Wakefield. This demonstrates how unrepresentative studies based on the experience of a single hospital may be. If the patients from Pinderfields for year one and year two are compared with patients in the other 13 hospitals similarly divided, a chi squared test gives a difference of 10.9 with one degree of freedom. The difference is significant ($P < 0.001$). Furthermore, if the monthly distributions of Pinderfields' patients in each year are studied, in the first year they appear lower than expected except in February, May, October and December. In year two the figures for May and January seem abnormally high. The full figures are given in Appendix 9. The spread of percentage changes across the hospitals indicates that it is not surprising to get one example like Pinderfields in a sample of 14 hospitals.

These results suggest that the figures from Pinderfields Hospital should be treated with some caution. However, there has been no change in the catchment areas, in the policies for admitting patients or in the management and data collection. It may be that the changes are due to random swings alone, and on balance it seems better to include these results. To exclude them would raise the suspicion that this was being done primarily in order to reach previously desired conclusions.

The size of this study, with 8237 patients in the first year and 6977 in the second is sufficient to give reasonable confidence in the findings, though it is not claimed that they are strictly representative of the whole of the United Kingdom. One of us (HRMH) examined the areas from which patients were coming and classified the hospitals into GB urban, GB mixed, GB rural and Northern Ireland. Table 1 shows this classification. Later on in the study some findings will be presented analysed by these types of location (see Sections 8.18 and 8.19).

6.2 Exclusions – Table 6

At hospital, forms were filled in for everyone who presented himself for examination following a car-occupant road traffic accident. Some of these people were found on examination to have no injuries. Policies about whether to create records for the uninjured varied from hospital to hospital. We decided that as records of uninjured car occupants were in any case incomplete it was more logical to analyse statistics for patients who had sustained injuries — so the uninjured were excluded. Also we originally intended to capture details of pre-hospital deaths. This proved impracticable in many centres and so for the sake of consistency we decided to exclude pre-hospital deaths everywhere. A separate study of deaths was undertaken with the co-operation of a number of coroners. This is reported in Part II, Chapter 11.

6.3 Belted status and seating position known and unknown

We attempted to collect the belted status and the seating position in all cases. However, inevitably in some cases the information could not be or was not collected. Table 7 shows the distribution of the known and unknown cases. The grand total of patients after exclusions was 14019, of which the seating position was known in 13536 and both seating position and belted status were known in 11932. These three groups have been designated (c), (b) and (a) respectively. In the great majority of the analyses the different seating positions have been shown, and these tables have all used (b) as their data base. In those tables which show belted status, (a) has been used as the data base.

Tables 8 to 14 compare the three groups alluded to in the previous paragraph in respect of age distribution, sex distribution, mortality, length of stay of inpatients distribution by Injury Severity Score, and distribution of Maximum Abbreviated Injury Scale. It is clear that in respect of all these factors the groups compare fairly well. The exclusion of the unknowns in seating position and belted status for groups (b) and (a) does create a certain bias, because the proportions of fatal and serious cases (ISS 25, AIS 4) are somewhat higher among those where belted status is unknown. The analysis of hospital admissions, bed stay and specific injuries on the basis of the more restricted data bases can, however, be accepted with reasonable confidence.

6.4 Classified and unclassified injuries

As explained on the section on methodology, in each region or subregion there was space for a full classification of only three injuries. A separate box was set aside to indicate the total number of injuries whether fully classified or not. Nought to eight total injuries were directly coded, but the digit 9 was used for a total of nine or more than nine injuries.

In the first year of the study there were nine patients who sustained nine or more minor injuries in a single region or subregion (see Table 25). Judging from the number of patients with six, seven or eight injuries, it appears that nearly all of these would have sustained nine injuries, and in only two or three patients is it likely that the nine indicates more than nine injuries. As the total number of classified injuries in the body was 19,467 in the first year, this is a negligible quantity. In the second year there was not a single patient with nine injuries or over in a region or subregion.

Table 15 shows the numbers of classified and unclassified injuries in each region, and in the body as a whole. Classification in any region always started with the three most serious injuries. In the external area, where all injuries are minor (AIS 1 or 2) the unclassified injuries are in the thousands, and in the first year amounted to 23.6% of the total. The unclassified injuries in the head and neck are likely to be minor injuries to the teeth and the inside of the mouth. Only in the abdominal and pelvic contents is it likely that the space was inadequate to classify all the serious injuries, and this only happened in a few cases in the second year.

The only injuries which are captured in the study are those which the doctors documented. Many trivial injuries may have been ignored, and in other cases entries such as "multiple small abrasions" were coded as nine abrasions.

All the main tables about patients and their injuries have been derived from those injuries which were fully classified. The unclassified injuries are only shown in Table 15. It is clear then that the picture given is a partial picture. All the same, the number of severe injuries unclassified is so small as to be safely ignored. In the case of minor injuries the true incidence is slightly higher than what is shown in our tables. However, the great majority of minor injuries have been classified. The two years have been similarly treated and comparisons are valid. It will be seen later that minor injuries in different regions and subregions form consistent patterns and that a great deal of useful information can be gained from their study.

7. Seating and belting distributions

Introduction

Table 16 has been extracted from the data of those patients for whom both the seating position and the belted status are known. Our original data contained unknowns for both these factors, and it must be accepted that the distribution of the belting or seating position may have been different among the unknowns. The relative percentages for seating position and for belted status in the table are reasonable approximations, but not exact figures.

7.1 Distribution of patients by seating position

Table 16 shows that there was a slight apparent change in the percentage distributions of patients for drivers, front seat passengers and rear seat passengers between years one and two. This is important for one possible reaction to the legislation would be that a passenger who objected to seat belts and previously had travelled in the front seat might change after legislation to travelling in the rear seat, so avoiding a compulsory belt. In the next two chapters it will become evident that the effect of belts was to decrease the number of front seat occupant patients in the second year, while the number of rear seat patients did not change significantly. This would account for the higher percentage of rear seat patients in the second year.

7.2 Ratios by seating position in the community and among patients

Table 17 shows distribution of people in different seating positions in the car expressed as ratios where the driver is counted as 1. As there is nearly always a driver in a car, this is a reasonable method of expressing the relationships.

We have no evidence for the exact ratios by seating position in 1982 or 1983. The figures quoted are from a traffic survey of 1978/79. It is thought that these ratios do not alter greatly from year to year.

In the first year of the study front seat passenger patients were slightly over-represented. The difference is small and could represent a change in car use, though it might also indicate that this position was marginally more dangerous than the driver's. The under-representation of patients in the back seat may suggest that this is a safer position in the car, as noted by Grattan and Hobbs (1).

In the second year the driver and rear seat passenger patients are in the same ratio as expected in the community. This would suggest that when 95% of drivers are belted, the driving seat is as safe as the back seat where 97% are unbelted.

In this year front seat passenger patients are under-represented. Ninety-five per cent belted motorists in this position would seem to make the position relatively safer than the similarly belted drivers or the unbelted rear seat passengers.

7.3 Belted and unbelted patients and motorists in the community

Table 18 shows the distributions of drivers and front seat passengers who were belted for the first and second years, both among patients and among motorists in the community. The figures have been separated into those for Great Britain and those for Northern Ireland. In Northern Ireland there is considerable variation in the proportions of belted drivers and front seat passengers in the community in different regions within Northern Ireland. As the great majority of patients were drawn from the Belfast area, the figures for motorists in the community in Northern Ireland given here are drawn from counts made in Belfast.

Before legislation the belting rate for drivers in Belfast was 13% below that in Great Britain, and for front seat passengers the rate was 18% lower. The difference is thought to be due mainly to the fact that in Great Britain the campaign to persuade motorists voluntarily to comply had been larger and sustained over a longer period. After legislation the gap in wearing rates fell to about 2% to 3%. Because the original figures for Northern Ireland were lower, the change in belt use was greater in Northern Ireland than in Great Britain.

We will start by examining the figures for Great Britain. As these are calculated on the basis of 7070 patients in year one and 5895 for year two compared with 1167 and 1082 for the two years in Northern Ireland, they are more likely to be accurate. In the first year among patients in Great Britain 26% of drivers were belted, that is 13% less than the percentage for motorists in the community. Twenty-three per cent of front seat passengers were belted, which is 19% less than the figure for motorists in the community. The discrepancy would be what one would expect if the belts were effective in preventing injury. The fact that in motorists in the community a higher percentage of front seat passengers were belted, and among patients a higher percentage of drivers were belted suggests that belts may have been more effective for front seat passengers than for drivers.

In the second year the difference in the rates between motorists and patients has fallen to between one and two per cent. If all motorists in the community were wearing belts, then all patients would also be belted. With wearing rates of 94% and 95% only small differences can be expected.

If we examine the figures for patients in Northern Ireland the figures for front seat passengers are similar to those in Great Britain, although the difference between patients and motorists in year one (5%) is less than in Great Britain, and the difference in the second year (4%) is greater. For drivers the second year contrast in Northern Ireland is very close to that in Great Britain. However, in the first year 27% of patients were said to have been belted against 26% of motorists in the community. This is a finding which is not easy to explain.

As far as patients go "Belted" means that the patient or someone supplying information on his behalf said that he was belted. It was originally intended to document whether the doctor or receptionist receiving this information felt convinced of its veracity. However, the instructions on the form relating to this were differently understood in different hospitals and so the resulting data had to be rejected.

The pressure to claim wrongly to be belted when the patient in fact had been unbelted was obviously much greater in the second year when it had become an offence to drive unbelted. From this point of view the consistently lower rates of between 1% and 4% for drivers and front seat passengers both in Great Britain and Northern Ireland are of the order that would have been expected in view of the findings of so many other studies that seat belts were effective. With a wearing rate of 92%–95% in the community one could not expect a differential much greater than this. The fact that the patient rates were 1%–4% lower in the second year strongly suggests that the great majority of patients must have reported truthfully to the doctors whether they were or were not belted.

The figures of 27% belted among drivers in Northern Ireland in the first year remains anomalous and unexplained. The contrast of this rate and the 19% rate for front seat passengers is surprisingly large, and this again casts doubt on the accuracy of the figures. It is a reminder also that these figures are not exact, and that great caution should be exercised in extrapolating from them.

7.4 Belted status of patients at different times of the day

Table 19 shows that the percentage of patients who were belted varied at different times of the day. The times chosen for comparison were periods each of which was thought to have a somewhat different social use from the point of view of transport. From 23.00–2.59 hours is a period dominated by social use — people returning to their homes after social activities. It is the time when alcohol related problems are most likely to be a large factor. 3.00–7.59 is a time of low road use, when people are asleep or having breakfast. 08.00–12.59 hours is morning with a mixture of work journeys, shopping and personal business journeys. 13.00–17.59 hours is much like the morning, and includes returning home from work by many. 18.00–22.59 hours is more social, though not so completely as the first period.

It will be noted that the second, third, fourth and fifth periods are five hour periods, but the first is a four hour period.

Table 19 shows that the percentage of front seat occupant patients (i.e. drivers plus front seat passengers) who wore belts was lowest in both years between 23.00 and 02.59 hours. The second lowest period in the first year was 18.00–22.59 hours and in the second year 03.00–7.59 hours.

In both years the period in which most accidents occurred was 13.00–17.59 hours. It should be remembered that the 23.00–02.59 hours period is only four hours.

Looking for the effect of legislation on accidents and injuries in these periods we selected mean Injury Severity Scores to test the effect. It can be seen that in both years the highest mean ISS scores are in the period 03.00–07.59 hours while the 23.00–02.59 hours period has almost as high scores. Compared with these, the morning, afternoon and evening mean ISS values are very considerably lower. Furthermore, while in these three relatively good periods the mean ISS improved in the second year in comparison with the first, the two periods with higher mean ISS scores also have worse means in the second year compared with the first. These worse scores have been sustained in spite of much better belting rates. At first sight this might suggest that during this period belting gave drivers a false sense of security and encouraged them to drive more recklessly. However, if we separate the scores into those for the belted and unbelted, the belted for the 23.00–02.59 hours period in the first year had a mean ISS of 2.93, and in the second year 2.80, whereas the unbelted in the first year had a mean ISS of 3.50 and in the second year a mean ISS of 4.59. The idea that the bad results of the second year were due to over-confident belted drivers is shown to be false. It is the very high scores of the unbelted which have resulted in the general deterioration.

7.5 Reference

(1) GRATTAN E, HOBBS J A. Some patterns and causes of injury in car occupants. Fifth International Technical Conference on Experimental Safety Vehicles, 1974.

8. Findings and Discussion

8.1 Introduction

Because of the great number of tables in this report, were the normal convention followed of reporting first the findings and then proceeding to the discussion, it would be necessary again and again to keep turning out two different sections of the report. For convenience therefore we will consider each table on its own, and proceed immediately from findings to discussion on each particular topic. However, detailed statistical argument is kept for Chapter 9, although cross references to that chapter will be made whenever it seems helpful.

8.2 Format of tables for comparison of injuries and patients before and after legislation

From Table 20 onwards, in many tables the column headings remain the same. The first two columns show figures relating to drivers in the first and second years. A third column shows the percentage change which has occurred between these two. This is followed by three similar columns relating to front seat passengers. It will soon become apparent that there are considerable differences between the results for these two seating positions. The next three columns relate to front seat occupants obtained by adding the figures for drivers and front seat passengers. This gives the figures for all those to whom the change in legislation directly refers. Next, figures are shown in three similar columns for the rear seat passenger. This position is to some extent a control for the front seat positions. Finally there are three columns to show the effect of the legislation on the totality of injured car occupants.

8.3 Deaths, admissions to the wards and outpatients — Table 20

As previously noted, prehospital deaths have been excluded. In the row for deaths are all the deaths which took place in hospital, whether this occurred in the accident and emergency department or in the ward. Those shown as ward admissions and non-admissions are the survivors.

It will be seen that there was a small increase in hospital deaths among drivers, a very small decrease among front seat passengers, and quite a marked decrease in deaths of back seat passengers, though these numbers are too small to allow useful conclusions to be drawn. The question of deaths will be considered more fully in discussion of the national statistics in the final section of this chapter and the study on fatalities obtained from coroners (see Part II, Chapter 11).

Considering outpatients and inpatients, it was predicted in our hypotheses that numbers would fall in the second year, and this has proved to be the case — an overall reduction of 25.2% of those admitted to the wards and of 12.6% of those not needing admission. Statistical testing showed that these changes were highly significant (Sections 9.1, 9.2 and 9.3).

Within the total, if we look first at the rear seat passenger, we can see that there is virtually no change: −4.4% for non-admissions and +5.9% for admissions. The changes in the front seat occupants are more pronounced than those in total patients (−14.2% for non-admissions, −29.9% for admissions). And finally if we examine front seat passengers and drivers to see if these improvements are equally shared by both groups, we find that this is not so. The improvement for front seat passengers (21.9% for non-admissions, 43.1% for admissions) is virtually double that for drivers (10.3% for non-admissions, 23.2% for admissions). When subjected to statistical testing these differences were highly significant (see Sections 9.2 and 9.3). In subsequent tables this contrast appears again and again.

Changes similar to ours have been reported from other countries. Dagnone and Siu (1) reported a decrease of 21.3% for drivers and 33.1% for front seat passengers in the year following seat belt legislation in Canada. Andreasson and Roos (2) report falls of 15% and 26% for drivers and front seat passengers from similar legislation in Sweden. In neither case was attention drawn to the significance of the seating position.

The first prediction from our hypotheses (that there would be a reduction in inpatients and outpatients) has been convincingly demonstrated. The scale of the change is sufficient to make a considerable impact on services required for treating accident victims.

8.4 Days in hospital — Table 21

This table is concerned with patients admitted to the wards, both those who survived and those who died. Considering firstly the number of bed-days, for all seating positions this has fallen by 25.2%, a substantial fall. Rear seat passenger bed-days increased by 5.1%, and the improvement for front seat occupants only is 29.2%. Again, front seat passengers have had more improvement than drivers (34.6% compared with 26.6%). The improvement is more marked in short-stay patients (0-2 days) and for those who stay more than 15 days. In the case of short-stay patients the reduction of 254 bed days can probably be completely accounted for by the fall in the incidence of minor brain injuries (385 less cases in the second year). The improvement for the intermediate group, though less, is still considerable. This also is a predicted change. Statistical testing again confirms that these are real changes (see Section 9.4).

8.5 Severity

8.5.1 Injury Severity Score — Table 22

The five degrees of severity were chosen to demonstrate significantly increasing degrees of severity. The first category would include patients with very minor injuries (AIS1), and one to three of these injuries. The most severe category would include patients with one extremely severe injury

(AIS5) though it would also include patients with a combination of somewhat lesser injuries. The table shows improvements at each of the five degrees of severity. There was little improvement in rear seat passengers at any degree of severity. In the lesser degrees of severity (ISS 1-3 and 4-8) the front seat passengers appear to have benefited considerably more than the drivers, whereas for the more severely injured (ISS9+) patient the improvement for front seat passengers is only a little greater than that of drivers. The statistical tests on these tables are found in Section 9.5.

8.5.2 Maximum Abbreviated Injury Scale — Table 23

As explained earlier, the MAIS is a classification of patients by their highest AIS injury. The distribution is shown for each MAIS on its own, but as the figures for MAIS 3, 4, 5 and 6 are small, these are also shown aggregated into a single group MAIS 3+.

The table again shows big differences between the effect of the legislation for different seating positions. For the front seat occupants with MAIS 1 and MAIS 2 there appear to have been proportionately much bigger decreases in front seat passengers than in the case of drivers. However, for the severe injuries this difference has disappeared, the decrease for drivers being 24.0% and for front seat passengers 23.3%. In the case of the drivers this decrease is greater than the decreases for MAIS 1 and 2 (11.6% and 14.0%), while in the case of front seat passengers the decrease of MAIS 3+ patients (22.3%) is less than that for MAIS 1 and 2 (23.6% and 37.0%). This conflicts with a finding of Bohlin (3) on reviewing the effect of Swedish legislation. He found that for injuries of AIS 3 and over drivers improved by 45% and front seat passengers by 66.5%.

For rear seat passengers the increases and decreases for the various severities of MAIS are all less than 6% — in some cases decreases, in others increases. In general there is little change in severity as measured by MAIS for rear seat passengers.

8.5.3 Distribution of Numbers of Injuries by Severity (AIS grades 1-6) — Table 24

A comparison of the numbers of injuries by severity in the two years shows that, as with MAIS, in the case of both drivers and front seat passengers there is no level of severity for which improvement does not take place. Again, the results for front seat passengers with injuries AIS 1 and 2 are substantially better than the improvements for drivers — for AIS 2 injuries the improvement is about double. When injuries of AIS 3+ are compared, the improvement for front seat passengers is 23.8% and for drivers 19.5% — a much smaller contrast than in the case of the less severe injuries.

For rear seat passengers, the number of AIS 1 injuries are reduced in the second year by 7.9% AIS 2 increased by 6.5% and AIS 3+ increased by 8.0%. The increases may partly be due to the fact that traffic increased by approximately 5% in the second year. It is possible that the decrease for AIS 1 injuries may be a real decrease. This will be discussed again in Section 9.5.3.

8.6 Multiplicity of injuries — Tables 25 and 26

The question of the multiplicity of injuries can be considered in two ways – in terms of absolute numbers and in terms of proportions of patients. It is quite clear in terms of absolute numbers that for both major and minor injuries, the number of patients with two, three, four or five injuries has fallen in the second year. so that if we ask "Were there fewer patients with multiple injuries in the second year?" the answer is "Yes, there were fewer".

However, we may also ask "Did those patients in the second year who received multiple injuries each have fewer injuries?". In the case of minor injuries the answer is "For drivers yes ($P<0.001$) and for front seat passengers, yes ($P<0.001$) but for rear seat passengers, no". For major injuries the answer is "No. The fall in patients with two, three, four or five injuries is just proportional to the overall decreases in the number of patients".

Therefore the effects of legislation on multiplicity of injuries has been in the case of minor injuries to reduce both the numbers and the proportions of patients with multiple injuries. For major injuries the legislation has reduced the numbers but not the proportions of patients with multiple injuries.

8.7 Casualties with specific injuries

This section may be considered central in the whole report, for while it is possible from national statistics to derive information about the numbers of dead and of serious and slighly injured casualties, only in a hospital based survey is it possible to examine the effects of legislation on specific injuries to specific organs. For ease of reference the tables are set out in alphabetical order. For all types of injuries figures will be given for the number of patients who sustained such injuries. In some cases this will be supplemented by a table showing the numbers of injuries.

8.8 Abdominal and pelvic contents — Table 27

All the numbers are small. The only organ which on its own sustained enough injuries for comparison of both driver and front seat passengers is the kidney. For both there was a marked improvement in the second year (50.0% for driver and 31.1% for front seat passengers). In the first year the ratio of drivers:front seat passengers is 1:0.62. In the community the ratio is 1:0.50 (see Table 17). Front seat passengers seem more vulnerable than drivers to this injury. In the second year, the over-representation of front seat passengers has increased, 1:0.84.

If all other injuries apart from renal are amalgamated, we find an 18.2% increase in driver casualties, and a 50% increase in front seat passenger casualties in the second year. The driver: front seat passenger ratios are 1:0.30 in the first year and 1:0.38 in the second — drivers seem more vulnerable than front seat passengers to this injury.

For both kidney and for all other organs, the improvement for drivers has been much better than for front seat passengers in the second year. The kidney is the most posterior organ in the abdomen. If a seat belt is incorrectly worn, in a crash it is quite possible for the lap section of the belt to cause abdominal injury, and this may well be the mechanism of injury for the non-renal organs. We have no data about correctly or incorrectly worn seat belts, but it should be remembered that over 80% of belts in cars in the community were inertia reel where correct positioning should be automatic. The contrast between renal and other abdominal and pelvic injuries was not expected, and therefore was not the object of any hypothesis. While we have amalgamated all non-renal injuries because the numbers of injuries to individual organs were so small, it can be seen that the increasing injuries occurred particularly in the gastrointestinal tract and the mesentery (documented as "other" in table 27). Statistical tests for drivers only seem to show a significant decrease in renal injuries (see Table 58), while for front seat passengers the figures do not reach the significant level (see Table 59). This unpredicted finding we treat with great caution. Its final confirmation must await studies carried out on new and different data bases.

8.9 Brain injuries — Table 28

In this table the injured patients are classified as minor and major. In this and subsequent tables unless otherwise stated, minor means an injury of severity AIS 1 or 2, while major is an injury of AIS 3 or over.

In this table it will be seen that drivers with minor brain injuries decreased by 34.2% and front seat passengers by 58.1%. Although classified as minor injuries some 50% may still have symptoms at six weeks after sustaining the injury and 15% may have symptoms at a year (Rutherford 4,5). Compared with an abrasion, contusion or wound in the skin, a minor brain injury is much more serious. It is also relatively common. That its incidence can be so greatly reduced is a notable benefit of the seat belt legislation. This was another injury where the front seat passenger gained very much more advantage than the driver. The rear seat passenger was neither better nor worse off. Our hypothesis about brain injuries was made in relation to all degrees of severity, and statistical tests show significant improvements. Minor brain injuries have been the major factor in this change (see Section 9.8).

In relation to major injuries the front seat passenger again improved, and while the improvement is less than for minor brain injuries (40.9% instead of 58.1%) it still is substantial. By contrast, 45.8% more drivers in the second year sustained major head injuries than in the first.

Also, as we proceed to examine other injuries, we will find that this is one of a group of injuries in the face and head, all of which have increased for drivers only (see Section 8.16.1). Each will be mentioned in its own section and at the end of the section on injuries we will discuss the significance of this whole family of head and face injuries which have increased in incidence among drivers in the second year. Numbers of patients in the rear seat with major head injuries are few, and unchanged in the two years.

The combined result for both drivers and front seat passengers shows a small overall increase in major brain injuries. This would appear to conflict with findings of Petty (6), that following seat belt legislation the annual rate of severe head injuries fell by 64%. He makes no distinction between drivers and front seat passengers.

This table shows the great advantage of classifying injuries by their severity. If the only figures available were the totals for brain injuries, a most interesting finding would have been missed.

8.10 Eye injuries — Table 29

For eye injuries the numbers are fairly small. In these figures we have followed the Abbreviated Injury Scale booklet, and classified eyelid and tear duct injuries as part of the eye. Drivers and front seat passengers appeared to gain very similar improvement, so if front seat occupant figures are considered, in most categories these are large enough to make some comment. Decreases of 44.4% for abrasions and 50.0% for foreign bodies are obviously worthwhile. Wounds of the eye were classified into minor and major, in this case AIS 1 and 2. The AIS2 injuries are the perforating wounds of the eye. While in minor wounds front seat occupants decreased by only 17.5% in major wounds the decrease was 83.3%. It seems possible that the major wounds are caused by being thrown forward till the head goes through the windscreen. It is likely that belting prevents this but may not be sufficient to prevent contact with the steering wheel, and the top of the dashboard. Some injuries may also be caused by fragments of glass striking the face of the car occupant at some speed.

These results compare well with the Australasian experience. Trinca and Dooley (7) reported a 16% decrease in eye injuries due to seat belt legislation, and Briner (8) reported that in the six and a half years before legislation the Princess Alexandra Hospital in Brisbane received 177 penetrating eye injuries per year which fell to 96 per year in the two and a half years following legislation.

Table 26 could also be looked at from the point of view that even a 95% belting rate does not of itself eliminate all lacerations and foreign bodies in the eyes. The case for laminated windscreens remains as stated by Blake (9).

8.11 Fractures and dislocations

Fractures and dislocations will be considered in a number of regions. Numbers of dislocations all over the body were too low to yield significant findings on their own, and so have been added in with fractures of the bone immediately distal to the joint in question.

8.11.1 Fractures/Dislocations in Extremities (lower) — Tables 30 and 31

Tables are given for both patients with injuries, and for injuries. The differences are not great and the table showing patients will be discussed (Table 31).

In minor fractures of the leg and dislocations of the knee, there was a very slight and probably insignificant increase in drivers in the second year. For front seat passengers there was an apparent decrease of 12.5%. However, for major injuries there was a decrease of 32.1% of drivers. Although the numbers for front seat passengers are small, there appears to have been an increase in patients with major leg fractures in the second year. In the first and second years the ratios of drivers to front seat passengers for patients with leg fractures was 1:0.29 and 1:0.38 compared with a ratio of 1:0.50 for motorists in the community (see Table 17). So for this injury drivers are very over-represented, more so in the first year than the second. This is another injury where the different configuration of the interior of the car seems to have played a part.

Patients with fractures of femur have decreased by 24.4% and 22.6% for drivers and front seat passengers — a good improvement equal for the two positions. The driver to front seat passenger ratios were 1:0.38 and 1:0.39 in the first and second year, which again is a marked over-representation of injured drivers.

8.11.2 Fractures/Dislocations in Extremities (upper) — Tables 32 and 33

Again comment is based on the table for patients with fractures (Table 33). For patients with finger fractures there was little apparent change in the second year for drivers or front seat passengers. Back seat passengers seem to show a 50.0% improvement with fairly small numbers. Patients with hand fractures appeared to improve by 54.2% for drivers and 42.9% for front seat passengers. The numbers are fairly small. Patients with forearm fractures decreased by 46.5% and 44.9% for drivers and front seat passengers. For arm fractures front seat passengers had a better improvement than drivers (−40.9% compared with −18.8%), calculations based on moderately small numbers. Front seat passengers seem to gain more improvement than drivers for clavicle fractures. It is to be noted, however, that there was improvement for both, −10.4% for the drivers and −43.7% for front seat passengers. This injury has sometimes been quoted as a seat belt injury, but there is no evidence in the study that seat belts have had a deleterious effect. Changes in the incidence of upper limb fractures had not been predicted, so statistical confirmation must await later studies.

8.11.3 Fractures/Dislocations, Extremities by left and right sides of body — Tables 34 and 35

Tables 34 and 35 show the effect of seat belt position on the side of the body which sustained limb fractures. Not surprisingly, drivers sustain more fractures in the right limbs and front seat passengers in the left limbs (in the United Kingdom the driver sits on the right hand side). The sides with most fractures are the sides where driver and front seat passenger are close to the outside of the car, and susceptible to direct trauma. There is one interesting exception to this general rule — front seat passengers sustained more forearm fractures on the right side. One might speculate that when being thrown forward right handed people instinctively try to protect themselves with their right arm. The proximity of the steering wheel may also be a factor.

Tables 36 and 37 show the distribution divided into first and second years. It appears that for drivers the effect of belting was to increase the dominance of right sided fractures in the second year, while for front seat passengers the left side was not as predominant in the second year as the first.

It has sometimes been suggested that clavicular fractures are seat belt injuries (see Section 8.17.2.2). In support of this it is pointed out that clavicular fractures among drivers in the United Kingdom are more common on the right side, and among front seat passengers on the left (Christian (19)).

However, in Table 35 it can be seen that the predominance to the right among drivers is virtually the same as for all other upper limb fractures. The predominance to the left among front seat passengers is slightly more marked. The distribution of clavicular fractures among belted and unbelted drivers and front seat passengers (Table 38) does not suggest any marked association between this injury and belting. It should be remembered that over the two years in question the approximate ratio of belted to unbelted front seat occupants in the community was 60:40. In the case of front seat passengers there is an apparently significant decrease in clavicular fractures after legislation (see Table 60).

8.11.4 Fractures and Dislocations in the Face — Table 39

These are set out as minor (i.e. AIS 1 or 2) and major (AIS 3 or over). Among drivers, there are interesting differences in the findings for different types of fracture. Drivers with malar fractures and nasal fractures seem to have increased in the second year, whereas for middle third fractures and mandibular fractures, numbers seem to have decreased in the second year. The only fracture with sufficient numbers to calculate percentage changes in front seat passengers was fracture of the nose where there was a decrease of 37.5%. This is a striking contrast to the 14.1% increase among drivers. The significance of the increased number of drivers with some facial fractures is discussed in Section 9.7.

The overall effect for all facial fractures was a 9.7% increase for drivers and a 45.8% decrease for front seat passengers. When all facial fractures are considered together the fall is statistically significant (see Section 9.7). The other apparent differences await confirmation in future studies.

Trinca and Dooley (7) reported a 50% decrease in severe facial injuries following seat belt legislation in Victoria, Australia. Hobbs (10) reported an incidence of facial fractures of 5.5% among the un-belted and 2.6% among the belted.

8.11.5 Fractures — Ribs and Sternum — Table 40

Fractured ribs were classified in accordance with the Abbreviated Injury Scale 1980 edition. This classifies fractures in several adjacent ribs in a single patient as one injury. We do not have details of the actual numbers of ribs which were broken, nor the specific identification of particular ribs.

The table has therefore been prepared showing numbers of patients who sustained rib fractures rather than the number of fractured ribs. The number of drivers with rib fractures seems to have fallen by 37.1% in the second year. For front seat passengers with rib fractures there was virtually no change in the second year. Drivers appear to be over-represented in the first year (ratio 1:0.34) but not in the second (ratio 1:0.55). In the community the ratio is 1:0.50 (see Table 17).

When we examine the number of patients with sternal fractures, we find a proportional increase of 100% in drivers and approximately 150% in front seat passengers. Such an increase had been predicted and when tested statistically was found to be significant, although the differences between the rates for different seating positions did not reach the point of significance.

Drivers were over-represented in the first year (ratio 1:0.38) but not in the second (ratio 1:0.48).

8.11.6 Fractures of the skull — Table 41

For drivers the picture is of virtually no change or possibly a slight increase, especially for minor fractures. For front seat passengers, the numbers are small, but it would appear that there was a definite improvement in the second year. It had been predicted that for skull fractures of all types there would be a fall in the second year, and this was confirmed with statistical tests (see Section 9.9). The differences between drivers and front seat passengers had not been predicted.

8.11.7 Fractures and dislocations of the spine — Table 42

Patients with cord damage are shown separately, although the numbers are too small to calculate percentages for comparison. All spinal injuries with cord damage are major injuries with an AIS of 3 or more. Those without cord damage have been divided into Minor (AIS 1 and 2) and Major (AIS 3 or over). Drivers with lumbar fractures appear to have decreased in the second year, and front seat passengers to have increased. The differences are small and were not predicted. If we amalgamate patients with fractures of all the regions of the spine there were fewer driver patients in the second year but no change in front seat passengers. This apparent change awaits further elucidation.

8.12 Sprains — Table 43

In our hypotheses, we predicted that neck sprains would increase as a result of mandatory seat belt legislation. This prediction was based on the analysis of injuries in Australia following the introduction of compulsory seat belt legislation by Cameron and Nelson (11). Statistical tests confirm that there has been a significant increase, and this also appears to be so on direct inspection of the table (Section 9.11). Statistical tests on the influence of seating position are inconclusive. There is a slight suggestion from inspection of the table that the deleterious effect has been worse for drivers than passengers. An apparent similar deterioration for quite large numbers of back seat passengers is an unexpected finding, which now awaits confirmation or otherwise in further studies.

Although Table 43 shows that neck sprain is a common injury after a car accident, it was thought possible that these figures, based largely on immediate examination after the accident, might not reveal the full extent of the problem. A further small study was conducted by a late examination of patients at one hospital. This is being reported elsewhere (12).

There was no prediction about lumbar sprains. Although the injury is not as common there appears to have been a considerable increase in patients with this injury, and in this case the front seat passengers appear to have done worse than drivers.

Sprains to individual joints in the upper extremities were few, but looked at in total (sprains to all joints), there was a 21.6% improvement for drivers and a 5.0% improvement for front seat passengers.

By contrast, in the lower limbs patients with sprains increased in the second year, +13.0% for drivers and +8.3% for front seat passengers. None of these changes was expected, so no statistical tests have been done. Further work may or may not confirm their significance.

8.13 Superficial injuries

8.13.1 Abrasions – Tables 44 and 45

There are relatively small differences between the table showing injuries and that showing patients. This may be partly because doctors rarely count up the exact number of separate abrasions, but merely mention these as abrasions in a particular area of the body. Abrasions so described were coded as a single injury.

As the two tables are much the same we will comment only on the numbers of patients who sustained abrasions (Table 44).

There was a very marked decrease in patients with abrasions in the face, both for drivers (–48.6%) and front seat passengers (–60.6%). This was predicted and statistically confirmed (see Section 9.6.1). For all intents and purposes rear seat passenger patients were unchanged. Among front seat passengers patients with abrasions on the scalp were much less common, and surprisingly for drivers such patients were marginally more common in the second year. Rear seat passengers with scalp abrasions increased in the second year. These apparent changes have not been statistically evaluated.

As regards chest abrasions there was an improvement for drivers and a deterioration for front seat passengers. The numbers are not large. There was virtually no change among rear seat passengers. Patients with abrasions in the upper extremities were 8.4% less for drivers and 49.3% less for front seat passengers. This was not expected and has not been tested statistically for significance. However, it is possible to speculate that the belt may prevent injuries against the dashboard and windscreen but not against the steering wheel. Patients with leg abrasions seem to improve by 25.8% for driver and 52.7% for passengers, possibly because of the different configuration of the compartment the driver having the steering column and pedals to contend with. This also was not suspected, and so this remains speculation only.

8.13.2 Contusions – Tables 46 and 47

This is another minor injury where the capturing of data was almost certainly inefficient, some bruising being lost because of insufficient space for classification, and some because of incomplete recording by doctors. In spite of this, in the classified contusions patterns emerge and the findings appear meaningful, especially in the context of other injuries to the same body regions. There were no very striking differences in the analysis of patients and injuries, so the table on patients with contusions will be discussed (Table 46).

There was a very marked reduction in patients with facial bruising, both for drivers and front seat passengers (–55.9% and –68.7% respectively). This was tested statistically and found significant (see Section 9.6.2). The differential between the two seating positions was distinct, yet compared with some other injuries relatively small. For rear seat passengers also there appeared to be a definite reduction in the numbers of patients with facial bruising. For scalp contusions we see again the peculiar change that drivers increased in the second year (+26.8%) and front seat passengers decreased (25.9%). As this was not predicted the change has not been tested statistically and it is possible that it may later be proved to have been a random swing. The fact that a similar change has already been seen for abrasion makes this less likely. Rear seat passengers with scalp contusions also increased in the second year (64.4%).

Neck bruising increased for car occupants in all seating positions. This was not predicted but it would seem reasonable to speculate that in the front seat it was probably bruising caused by the belt. In the rear seat the numbers are small, but it may possibly be connected with being thrown against a firmly anchored front seat.

Bruising to the chest wall was classified as either superficial (in the skin or superficial tissues) or deep (in the muscles and ribs). In superficial bruising, drivers decrease very slightly in the second year (−2.1%) whereas front seat passengers increase by 46.5%. Drivers are over-represented in the first year and under-represented in the second. We might speculate that bruising of the chest on the steering wheel is common in the unbelted, and when a belt is worn it is usually replaced by bruising from the belt. Rear seat passengers show a moderate decrease for all chest bruising −11.5%.

In the abdominal wall there was a fall of 20.0% incidence for the drivers with contusions and an increase of 42.1% for front seat passengers. The numbers are fairly small, and the apparent change was not predicted. However, it does appear somewhat similar to a change that has already been noted in some major internal abdominal injuries. It is possible that in the front seat passenger position one is often injured by the belt alone.

There was an interesting apparent decrease in bruising in the back for both drivers and front seat passengers. This was unpredicted and so has not been statistically tested.

Improvements for upper and lower extremities were also of a similar order for both drivers and front seat passengers. They were not predicted and have not been specifically tested.

8.13.3 Wounds – Tables 48 and 49

Like the tables for contusions and abrasions, the tables for wounds refer to minor wounds. Those inside the mouth and in the eyes were originally classified in the head region (following the format of the Abbreviated Injury Scale 1980 edition) but in these tables are shown along with wounds in the external region. Nearly all these wounds will have been sutured. It is much more likely therefore that doctors documented them fully. It is also less likely that such injuries were relegated to the unclassified section.

If injuries are compared with patients (Table 47 with Table 48), there are many more injuries than patients. However, as in most types of injury we have used the table for patients as the basis of analysis, we will stick to patients in this case also.

For patients with facial wounds, improvements of 44.0% for drivers and 62.7% for front seat passengers can be considered very satisfactory. Statistical tests confirm their significance (see Section 9.6.2). An improvement of 10.7% for rear seat passengers could possibly occur from the change in environment in the rear seat but the result is statistically untested and may be a random swing. Patients with scalp wounds show a 28.3% improvement for drivers and 37.6% for front seat passengers. There was, however, an increase of 27.1% in the numbers of patients with scalp wounds. These results are unpredicted and unconfirmed. It is interesting that abrasions and contusions among drivers should increase in the second year, whereas wounds in the scalp decrease. In may be that the wounds resulted from contact with the windscreen, a contact which has been greatly reduced, whereas bruises and abrasions result from contact with the steering wheel, which has actually increased (see Section 8.16.1).

For neck, chest, abdomen and back, numbers are insufficient in each subdivision to make proper comparisons. If these four areas are amalgamated into an area which we might roughly call 'trunk' and in this case if we amalgamate the injuries in these areas (Table 48), there appears to have been a 63.6% decrease in drivers' injuries and 52.2% decrease in the injuries of front seat passengers. This is another unexpected and therefore untested finding which may yet be confirmed in further studies.

For the upper extremity an apparent improvement for drivers with wounds was 30.3% and for front seat passengers 37.6%. For lower extremities the corresponding apparent improvements were 28.2% and 47.7%. Front seat passengers again seem to have improved more than the drivers. Rear seat passengers also seem to have derived a 21.5% improvement. None of these changes were predicted nor confirmed.

8.14 Thoracic contents – Table 50

Injuries to lungs, bronchi and pleura (including pneumothorax and haemothorax) have been amalgamated, as have heart injuries and ruptures of the aorta. The improvement for drivers in the former group was 33.3% and for front seat passengers 58.3% (though for the latter the numbers are somewhat small). These changes were predicted and have been shown to be significant (see Section 9.13). For heart and major vessel injuries the numbers are too small to calculate percentages for comparison, but there would appear to have been an improvement. As chest injuries and head injuries are often associated, and as they interact unfavourably, this marked improvement in chest injuries would be expected to affect morbidity and mortality. In injuries of the thoracic contents, drivers are over-represented with driver:front seat passenger ratios of 1:0.38 in the first year and 1:0.22 in the second.

8.15 Miscellaneous injuries

8.15.1 Burns – Table 51

There were technical problems in coding burns injuries. Our system was constructed to show the presence or absence of burns in each specific body region, and for all other injuries it was possible to show the AIS score of the injury within that region. For burns the AIS scores are calculated on the percentage of burned skin in the whole body. This is not susceptible to division by areas.

The main lesson to be learned from this table is that among patients who arrive alive at hospitals, burns are rare injuries. Seat belt legislation does not seem to have made any difference to their incidence.

8.15.2 Tooth injuries — Table 52

There is a possibility that these injuries have been incompletely recorded. However, from the available data it appears that both drivers and front seat passengers showed improvements, the latter more than the former. This is an unexpected and unconfirmed finding.

8.16 Injuries grouped in anatomical regions — drivers and front seat passengers

In Tables 53 to 58 injuries have been grouped together not in the Abbreviated Injury Scale areas, but in ordinary anatomical regions. The injuries from the various external subregions have been redistributed so that one can get a picture of all injuries which are related together. Thus, abdominal wall bruising and injury to abdominal organs appear in one table, and superficial injuries to back and spinal injuries in another.

In each table the upper half shows the injuries where there appears to have been a decrease in patients in the second year. The second half of the table shows injuries where the patients appear to have increased in the second year, in the case of either drivers or front seat passengers or both. Only injuries with enough patients to merit percentage change comparisons have been included in these tables. For this purpose they were deemed worth comparing if the total numbers in two years were 25 or more in the case of major injuries, and 50 or more in the case of minor injuries.

8.16.1 Head and neck — Table 53

This is an area with many injuries. If comparison is made with other regions it appears to be the most highly injured area in the body. For the first 10 of these categories of injury, there appear to have been substantial improvements in the second year for both drivers and passengers. They include minor brain injuries, eye injuries (including those likely to cause blindness), fractures of the middle third of the face and of the mandible as well as most wounds, contusions and abrasions in that area.

If we turn to those categories of injuries where there was an apparent deterioration in the second year, it should be noted that for front seat passengers there is only one such. For all intents and purposes in the head and neck the legislation appears to have been entirely beneficial for front seat passengers.

The position in regard to drivers appears considerably different. The most potentially serious finding is the apparent increase of patients with serious brain injuries of 43.8% (see Section 8.9). Although numbers of major brain injuries are not significantly different, the distribution between driver and front seat passenger has altered (see Section 9.8.2). When we see also that in this same region there appears to be an increase in drivers with scalp contusions, scalp abrasions, fractured malar bones, fractured noses and fractured skulls, and that in every case there seems to have been a decrease of front seat passengers with these injuries, there is a strong impression that some mechanism is operating which causes an increase of these injuries to drivers.

This seemingly surprising result, while not mentioned in our own predictions had certainly been anticipated and expected from previous work. Mackay (13) reported on studies both with dummies and cadavers showing that inertia reel belts allowed contact between the driver's head and the steering wheel (See Appendix 10). Gloyns et al (14) in a study of 250 vehicle accidents in which belted drivers were seriously injured showed that in 67% of frontal impacts the only contact of driver's head and face was on the steering wheel.

One may speculate also on why among drivers, patients with nose and malar bone (or cheek bone) fractures are more common in the second year while with fractures of the middle third of the face and of the mandible, they are less common. A possible explanation is that the nose and malar bone are both prominent and supported by very thin sheets of bone. The mandible is a much stronger bone, and the middle third of the face does not protrude like the nose, cheek or chin. These factors have not been proved to be significant, but common sense suggests so. It is obviously an area which demands further study.

8.16.2 Thorax — Table 54

Table 54 seems to suggest that the belt is quite efficient at protecting the internal organs of this region but that the chest wall does not derive as much benefit. In the first year drivers with injuries to the chest wall are over-represented compared with the proportions of drivers to other seating positions on motorists on the road in all three categories of injury. This is confirmed by Grattan and Hobbs (15). This suggests that before legislation many drivers injured their chest walls against the steering wheel. It is interesting that for rib fractures, there were 37.1% fewer driver patients in the second year. For front seat passengers the increase is very small and should probably be ignored. In the second year front seat passengers appeared to sustain contusions of the chest wall and fractures of the sternum much more commonly. For drivers, contusions were virtually unchanged, and fractures of the sternum seem to have increased to a lesser degree than for front seat passengers. It should be noted that in some cases of fractured sternum the heart will be bruised, and it is possible to develop a secondary coronary thrombosis.

8.16.3 Abdomen — Table 55

As noted previously, there seems to have been a good improvement in patients with kidney injuries in year two for both drivers and front seat passengers. For injuries to the remaining organs there are apparent increases for front seat passengers and drivers, and for contusions of the abdominal wall there again appears to be a substantial increase of front seat passenger patients and a 20% decrease among drivers. Even for the non-kidney organs, the drivers appear to have done less badly than the front seat passengers. We have already speculated that this might be due to the contact between chest and wheel, between knee and steering column or between feet and pedals or floor. Any of these or a combination of them might help to reduce the pressure of the belt on the driver's abdominal wall. Ryan and Ragazzon (16) comparing abdominal injuries before and after seat belt legislation in Victoria, Australia, report decreases in injuries in St. Vincent's Hospital, Melbourne, not only to the kidneys but also to the liver. Spleen injuries were almost unchanged and injuries to the gastrointestinal tract, the mesentery and the pancreas had increased. This largely confirms our own findings.

8.16.4 Spine and back — Table 56

For abrasions and contusions of the back, fractures, dislocations and fracture-dislocations of the cervical spine, the second year seems to have shown a reduction among drivers and front seat passengers.

It was predicted that cervical sprains would increase and this was confirmed statistically (see Section 9.11). Differences in the effects on patients in the different seating positions were not demonstrated.

The increases for patients with lumbar sprains which were not predicted appear to be proportionately greater, and in this case the front seat passengers seem to have come off worse. For lumbar fractures there appears to be a small improvement for drivers and a small deterioration for front seat passengers. While these may only be random variations one could speculate that being flexed and rotated across the oblique strap of the belt might cause such injuries. Also the presence of the steering wheel might have a certain stabilising effect upon the lumbar spine for the driver. A possible explanation might be that the front seat passenger is more often injured by an unbelted rear seat passenger, as when there is only one rear seat passenger he/she tends to sit in this position rather than behind the driver, but we have no evidence to substantiate this.

8.16.5 Extremities — Lower — Table 57

The injuries with apparent improvements for both drivers and front seat passengers are abrasions, contusions, wounds, fractures of the femur and of the pelvis. With the exception of the pelvis, the front seat passengers appear to have gained more advantage than the driver. For drivers, there seems to have been more patients in the second year with sprained ankles, sprained knees and fractured feet and ankles but the numbers of patients and percentage changes are small. The percentage increase of front seat passengers with sprained ankles is a bit larger (+35.7%) but the numbers are still small.

Patients with fractured legs have apparently decreased by 7.2% for drivers and increased by 21.4% for front seat passengers. It is interesting to note that front seat passengers with wounds on the legs seem to have fallen by 47.7%. While these changes could be caused by random swings there is also the possibility that wounds are caused in the less severe impacts and fractures occur when the front compartment of the car is much more grossly distorted.

8.16.6 Extremities — Upper — Table 57

For abrasions, contusions, wounds, sprains and five different fractures, there appears to have been improvement for all front seat occupants. There are no injuries in this region for which there are increases in patients in the second year. For three injuries the front seat passengers seem to have gained considerably more improvement than the drivers. For the remainder the differences are mostly small.

8.17 Profit and loss account for each seating position — Tables 59 to 61

In considering injuries caused by road accidents, we started by looking in turn at a number of specific injuries (Sections 8.7 to 8.15). We then looked at distributions seen as groups of injuries within different anatomical areas (Section 8.16). We now look at the total resultant effect to the driver, the front seat passenger and the rear seat passenger.

In these comparisons the overwhelming changes have been decreasing number of patients and injuries in the second year and these have been set out on the left hand side of Tables 58–60. However, it is important also to see those injuries which appear to have increased since legislation, and these adverse effects are set out on the right of the same tables.

By far the most important injuries are the major injuries, for these are those most likely to affect mortality and disability. They are shown in the top of the tables, and as elsewhere in this report they are injuries with scores of AIS 3 or over.

In order to prevent the most important injuries being obscured by a mass of detail concerning those injuries which occurred rarely or where the change was very small, we have only shown figures for major injuries where there were at least 25 patients involved in the two years and where the percentage change was over 0.05%. For minor injuries the corresponding limits are 50 patients and 0.1% change. In reading the tables the key column on which to focus first is that showing the change in the number of patients in the two years. It will be seen that the injuries have been ranked starting with the injury with the greatest change in the number of patients. The total numbers of patients from which this change was deduced are shown on the left.

To the right of the change shown in absolute numbers is the same change shown as a percentage. The percentage is relative to the total number of casualties in the relevant seating position for both years. For example, there were 7659 casualty drivers in the two years. The change in the number of casualties with injuries in the lungs and pleura was −21, indicating an overall decrease of 0.27 per cent. We consider this to be a better way of representing the change than by reference to the number of patients with that particular type of injury because the latter exaggerates the importance of injuries with small incidences. For example, the numbers of drivers with tooth injuries in years one and two were 48 and 27 respectively. This is a fall of 44 per cent, but relative to the 7659 casualty drivers is a fall of only 0.3 per cent. Thus the tables show more clearly the relative importance of differing injury types.

It will be seen that for these tables the probability that the seat belt makes no difference (the P value) has been calculated for each injury independently. Beside this is indicated with an asterisk those cases where a difference was predicted in our original hypotheses. It is only in those cases where there was such a hypothesis and the P value reaches a significantly low figure that we would confidently claim that a real change has been demonstrated. For the other injuries showing "significant" levels we would only say that a sufficiently strong suspicion had been indicated to justify making these injuries the basis of hypotheses for further studies.

8.17.1 Drivers — Table 59

8.17.1.1 Major Injuries

There were five types of injury with sufficiently large numbers of patients which show a decrease in drivers with these major injuries — lungs and pleura injuries, fractures of the forearm, of the thigh and of the leg, and kidney injuries. Only the first (lung and pleura injuries) had been predicted, and was statistically confirmed. Fractures of the forearm and kidney injuries also appear to show a significant P value, and even the other apparent improvements (thigh and leg fractures) look substantial and may well be proved by further work to be genuine effects of wearing seat belts. The improvement in lung injuries is particularly welcome, because such injuries often result in anoxia and even death. The anoxia (lack of oxygen) is especially harmful in the not infrequent co-existence of a head injury with a chest injury.

There were two major injuries showing deterioration in considerable numbers of patients — abdominal organs other than kidney injuries and brain injuries. Further work will be needed to see which abdominal injuries if any cause this increase, and whether or not it can occur with correctly worn belts. Examination of Table 27 on abdominal injuries would suggest that injuries to the gastrointestinal tract and mesentery (included in peritoneum and others) were the main contributors, and this would confirm reports in many previous papers (Ryan and Ragazzon (16) and Vellar et al (17)).

As regards major brain injuries, the significance of this change has already been fully discussed in Sections 8.9, 8.16.1 and 9.8.2.

8.17.1.2 Minor Injuries

There are many minor injuries where the numbers of drivers are above our required limits. The list of decreases is headed by wounds of the face, contusions of the face, minor brain injuries and abrasions of the face, all of which were predicted to fall. Lower down comes eye injuries which were also predicted to decrease. These changes were all statistically confirmed as significant. The improvement in minor brain injuries is particularly welcome, although it is proportionately much less than for front seat patients. Of the remaining 13 lesions where drivers decreased in year two, in six the probability appears highly significant ($P < 0.001$) and in only four is significance not reached. As these changes were not predicted we treat the results with some caution but clearly those are areas which demand special attention in future study. The decrease in fractures of the ribs ($P < 0.001$) is interesting in view of some references to this as a seat belt injury (Williams and Kirkpatrick (18)). It is possible that sometimes seat belts may cause a rib to fracture, but the overall effect appears to be to protect the ribs of drivers.

Of minor conditions where there was an increase in drivers in the second year, two were predicted and have been shown to be statistically significant — sprains of the neck and fractures of the sternum. Contusions of the neck and scalp were not predicted and the apparently significant P values must be treated with caution. Common sense would suggest that the bruises on the neck were directly caused by the belt.

8.17.2 Front Seat Passengers — Table 60

8.17.2.1 Major Injuries

For front seat passengers the major injuries which were sufficient in number to comment on, and which appeared to improve in the second year were injuries to lungs and pleura (which was predicted and is significant) major brain injury, major thigh injury and kidney injuries. Only one major injury with sufficient numbers showed an apparent increase, that was abdominal injuries for all other organs except the kidney. This was not originally predicted, nor does its P value reach a significant level. However, an apparent increase in drivers with these same injuries is also seen, and the comments made in regard to drivers apply also to front seat passengers.

Although there may be a real increase in some abdominal injuries, on balance front seat passengers have far more improvements than disimprovements. The reduction in major chest and brain injuries is especially likely to contribute to saving of life.

8.17.2.2 Minor Injuries

As regards minor injuries, improvements were predicted for wounds of the face, contusions of the face, minor brain injuries, abrasions of the face, minor facial fractures and eye injuries. In all these the predictions were confirmed as being significant. Of the remaining 11 injuries, there were only two which do not also show a significant P value. At this stage we can only say they require to be predicted and tested in further studies.

Of particular interest is the apparently significant decreases in fractures of the clavicle. Christian (19) mentions this as an injury increased by seat belts especially on the side on which the belt crosses the clavicle. Table 38 shows our figures for clavicles on the left and right for drivers and front seat passengers. The predominance of rightsided fractures in drivers and leftsided in front seat passengers is little different from the predominance of the sides in fractures of the arms and legs (see Tables 34–38).

The only minor injury with even a moderately large increase was bruising of the chest wall. It seems strange that this was not predicted. No doubt in some future study it will be. A small increase in sprained necks is not significant when tested for front seat passengers only, but is part of a significant increase for all car occupants. Some increased bruising to the neck is understandable and unimportant.

Taking both major and minor injuries, the improvements are very substantial and impressive. In comparison the disimprovements are few in number and proportionately small.

8.17.3 Combined Drivers and Front Seat Passengers

For both positions the advantages of seat belts would appear very greatly to outweigh the disadvantages. The advantages while substantial for drivers are obviously greater for front seat passengers. The disadvantages are very small for front seat passengers and somewhat greater for drivers.

The aim of improvement in seat belt design should be to prevent major brain injuries in drivers, to prevent abdominal content injury and fractured sternums for both drivers and front seat passengers. As sprained necks may have considerable long term consequence, much thought needs to be given to the prevention of this injury. In preventing brain and facial injuries in drivers, the solution may be in pre-loading inertia reel belts (Dejeammes et al (20)) (see Appendix No. 10).

8.17.4 Rear Seat Passengers – Table 61

The legislation about mandatory seat belt wearing applied to the front seats only, and it was not anticipated that there would be any marked change in the rear seat. The numbers of patients with major injuries of various types never totalled over 25 for the two years combined, and so do not reach our minimum required for comment. If we examine all rear seat passengers with MAIS of 3 or over (Table 17) there were 53 in the first year and 56 in the second, an increase of 5.7% on the first year. The differences may well be a random variation.

In considering minor injuries, there are a fair number with more than 50 patients in the two years. It might be thought at first that all these swings are purely random variations. However, for three of the decreases (contusions of the face, wounds of the face, and contusions of the back) and one of the increases (contusions of the scalp) the P value would normally be considered significant. Furthermore it is noticeable that contusions, abrasions and wounds of the face appear to form a group with minor facial fractures and minor brain injuries. The fact that abrasions and contusions in the scalp and neck injuries increased at the same time is a pattern which we have already seen for drivers. The second improving group of minor injuries are those in the lower extremity – contusions, abrasions and wounds.

While therefore we must be extremely tentative, there appear to be some grounds for thinking that belting of front seat passengers has altered injury patterns for rear seat passengers and this might possibly arise from alterations in their environment. Presumably belted drivers and front seat passengers help to keep the backs of front seats in a stable position, and rear seat passengers tend to be thrown against this rather than against collapsing seats. It is tempting to speculate that while the firm back of a front seat is a good surface to be thrown against, the deceleration forces of the rapid stop are increased, hence leading to an increase in sprained necks.

8.18 Location, GB urban, GB mixed, GB rural, Northern Ireland

As explained when giving details of the 14 hospitals in the survey, those in Great Britain were classified according to the predominant type of accidents admitted as being Urban, Rural or Mixed, and the Northern Ireland hospitals were treated as a separate group. No hypotheses were made about the effect of the type of location where accidents occurred. The tables have been prepared to give some rough indication of the amount of variation that might occur between different hospitals because of different types of catchment areas.

As regards belted status of front seat occupants (Table 62) it will be seen that the percentage of belted patients varied in the first year from 24.1% in GB urban hospitals to 30.9% in GB rural hospitals and in the second year from 87.0% in GB urban areas to 96.0% in GB rural areas. The Northern Ireland figures were close to the GB urban figures.

In relation to the admission to wards or non admission of patients (Table 63), among non admissions, the greatest change was seen in the GB urban hospitals and the least in the Northern Ireland hospitals. GB rural hospitals were close to the Northern Ireland figure.

For patients admitted to wards, the improvements for all groups in Great Britain were not very different (24.9% to 30.3%) but in Northern Ireland the fall in admissions in the second year was 40.8%. The reason for this is not clear, but it must be remembered that the improvement in deaths in the national statistics was also greatest in Northern Ireland.

The effect of location on the severity of injuries (Table 64) was assessed by looking at the distribution of Maximum Abbreviated Injury Scales. These were divided into those with MAIS 1, MAIS 2 and those with MAIS 3 or over. For those whose Maximum AIS was 1, Northern Ireland had the least improvement (3.0%), followed by GB rural with 7.5%. GB urban had 18.9% improvement and GB mixed 18.9% improvement. For MAIS 2 the GB rural improvement was the lowest (12.7%) and GB urban the highest (31.7%). For the most severe injured group (MAIS 3+) the GB urban had the lowest improvement (20.0%) and Northern Ireland the highest (28.6%).

The satisfactory change in Northern Ireland may partly be explained by the fact that the change in the percentage of belted motorists in the community between the two years was greater in Northern Ireland than Great Britain.

8.19 Survey findings within the context of the National figures

The hospitals in the survey were fairly widely scattered throughout the United Kingdom (see comment in Section 6.1). However, national road statistics are published separately from the Department of Transport in London for Great Britain and from the Department of the Environment in Belfast for Northern Ireland. Unfortunately methods of classifying and tabulating road casualties are different in these two areas. As the figures for Great Britain are more complete and detailed, separating front seat occupants and rear seat passengers of the car casualties, we will use Table 65 showing deaths and serious injuries in Great Britain as the national norm.

In the national statistics, serious injuries are defined as those cases admitted to hospital wards as well as patients with fractures of long bones and extensive wounds even where the patient has not been admitted. They are thought to approximate fairly closely to injuries to AIS 2 or over. For comparison in our study, we may examine patients with Maximum Abbreviated Injury Scale of 2 or over.

In the first year there were 1669 front seat occupants with MAIS 2 or over, and in the second year 1298 (Table 23). This is a decrease of 22.2%. The national figures suggest a decrease of 24.6%. The difference between the two is 2.4%. We conclude that as far as the percentage decrease in serious injuries to front seat occupants go, the results of our study closely approximate to the national figures. For rear seat passengers we had 286 patients with MAIS of 2 or over in the first year and 290 in the second. This is an increase of 1.4%. National figures show a decrease of 3.2%. The two figures are both close to zero and approximate reasonably well.

If we examine the MAIS 2+ front seat occupants for our four different locations within the United Kingdom, we can abstract the following figures from Table 64:

	First Year	Second Year	Change
Great Britain Urban	354	250	−29.4%
Great Britain Mixed	761	607	−20.2%
Great Britain Rural	305	256	−16.1%
Northern Ireland	249	185	−25.7%

It can be seen that the variation between different locations within our study is much greater than the difference between our study as a whole and the national figures.

As our hospitals were chosen primarily as centres from which we felt we would be able to get reliable data over a two year collecting period, and only secondarily as representative of the country as a whole, we have been cautious about using our figures to extrapolate to predict national changes. This comparison between serious injuries in the national figures for car occupants in Great Britain and MAIS 2+ injuries within our series suggests that our figures may well be representative of national trends, but that in specific hospitals or regions the results may vary by 5% – 10% depending on the type of roads on which accidents occur.

As far as deaths are concerned, the national figures show a decrease of 23.2% for front seat occupants. In our study of fatalities (see Part II) based on data from coroners, front seat deaths decreased by 31.8%. It should be noted that these coroners were all in Great Britain. The national figures for rear seat passenger deaths show an increase of 15.3% while our figures show an increase of 15.4%. The closeness of the two figures is partly due to chance, for our numbers of rear seat passengers were so small that a difference of one or two deaths would have greatly altered the percentage change. The difference of 8.6% between national figures and our figures for deaths among front seat passengers is small enough to suggest that in this respect also our sample is reasonably representative of the national figures.

From Table 23 one can abstract the total number of patients with a Maximum Abbreviated Injury Scale of two or over. This is equivalent to 5.6% of the Great Britain national figures, and our total deaths from coroners (180) is 3.9% of the deaths in Great Britain.

8.20 References

(1) DAGNONE L, SIU T O. Restraint system utilisation and its consequences among victims of motor vehicle collisions in South East Ontario. Ministry of Transportation and Communications, Ontario 1982.

(2) ANDREASSON R, ROOS K. Effect of Sweden's seat belt law. Proceedings of Sixth Conference of the International Association of Accident and Traffic Medicine, Melbourne 1977, p45.

(3) BOHLIN N. Fifteen years with the 3 point safety belt. Proceedings of the Sixth Conference of the International Association of Accident and Traffic Medicine, Melbourne 1977.

(4) RUTHERFORD W H, MERRETT J D, McDONALD J R. Sequelae of concussion caused by minor head injuries. The Lancet, January 1, 1977, pl–4.

(5) RUTHERFORD W H, MERRETT J D, McDONALD J R. Symptoms at one year following concussion from minor head injuries. Injury 1978, Vol. 10, p225–230.

(6) PETTY P G. Influence of seat belt wearing on the incidence of severe head injury. Med J Aust 1975, 768–769.

(7) TRINCA G W, DOOLEY B J. Effects of seat belt legislation on road traffic injuries. Aust N 2 J Surg 1977, 47, 675–678.

(8) BRINER A M. Penetrating eye injuries associated with motor vehicle accidents. Med J Aust 1976, 1, 912–914.

(9) BLAKE J. Road Blindness. Brit Med J 1983, 287: 626–627.

(10) HOBBS C A. Car occupant injury patterns and mechanisms. Eighth International Conference on Experimental Safety Vehicles. Wolfsburg 1980.

(11) CAMERON M H, NELSON P G. Injury Patterns with and without seat belts. Sixth International Conference of the International Association for Accident and Traffic Medicine, Melbourne 1977.

(12) RUTHERFORD W H, DEANS G T, MAGALLIARD J N. The frequency of neck pain among patients in car accidents, and the length of disability (in press).

(13) MACKAY G M. Seat belts in Europe – their use and performance in collisions. International Symposium on Occupant Restraint, Toronto 1981, American Association of Automotive Medicine, Illinois, USA.

(14) GLOYNS P F, RATTENBURY S J, RIVLIN A Z, HAYES H R M. HANSTEAD J K, PROCTOR S. Steering wheel induced head and facial injuries among drivers restrained by seat belts. Proceedings of IRCOBI Conference, Salon de Provence, France 1981.

(15) GRATTAN E, HOBBS J A. Some patterns and causes of injuries in car occupants. Proceedings of Fifth International Conference on Ex-

perimental Safety Vehicles, London 1974, Published U.S. Department of Transportation, p433–440.

(16) RYAN P, RAGAZZON R. Abdominal injuries before and since seat belt legislation in Victoria. Aust N 2 J Surg 1979, 49, p200–202.

(17) VELLAR I D, VELLAR D J, MULLANY C J. Rupture of the bowel due to road trauma: the emergence of the 'seat belt syndrome'. Med J Aust 1, 694–699, 1976.

(18) WILLIAMS J S, KIRKPATRICK J R. The nature of seat belt injuries. J Trauma 11, 207–218, 1971.

(19) CHRISTIAN M S. Non-fatal injuries sustained by seat belt wearers: a comparative study. Brit Med J 2, 1310–1311, 1976.

(20) DEJEAMMES M. Improvement of the automatic belt: the possible efficiency of the pyrotedinic retractor. ONSER Lyon 1979.

9. Statistical analysis

9.0 Introduction

In any major survey such as this with many variables and cases it is tempting to indulge in data-dredging: continuing to look through the data to discover effects that have not been thought of beforehand. It is always possible to think of new ways of presenting the data as we dredge through it and to think of new effects to test. This would certainly lead to spurious inferences and an endless waste of time.

To avoid this danger, we stated in advance a small number of the most important hypotheses. Although we have not restricted our statistical analysis to these hypotheses, we have confidently claimed statistical significance only when it has been based on a prior hypothesis. Any other interpretation of the data presented in all the tables should be related to the inferences drawn from the analysis of the previously stated hypotheses.

We have, however, indulged in some data-dredging: looking for interesting features within the data. Our findings are shown in the last section of this chapter on statistical analysis: the section we call the profit and loss account. These tables and the associated statistical tests should be read with great caution. They should not be regarded as a set of conclusions but as a guide to stating prior hypotheses in future studies.

The prior hypotheses in this study have already been stated (see Section 5.6). They are restated below in the form of inferences drawn from the data. They were constructed in terms of predictions and on the basis of papers written by Cameron and Nelson (1) and by Nelson (2).

The inferences are numbered and they are concisely stated. The numbers cross refer to later sections in which the hypotheses are presented as questions which are answered by a description of the corresponding statistical analysis.

The hypotheses and statistical tests mostly relate to changes between year one and year two, and are made on the data for which seating position is known whether or not the belted status is known. However, in some sections, we proceed to ask if the change may be attributed to the use of belts. Here the belted status must be known as well as the seating position so the total number of casualties will be less than when disregarding the belted status (see the distinction between groups (a) (b) and (c) in Table 7, and the comment in Section 7.3).

It should be remembered that the statistical analysis is of data from 14 hospitals which, although not randomly selected, we believe to be generally respresentative of UK hospitals.

A prior hypothesis is usually stated as a positive prediction. For example, "There will be a reduction in the total number of patients". For the purpose of statistical testing this is restated as a null hypothesis: "There will be no changes in the total number of patients". The statistical test involves the probability (P) of the observed number of patients occurring by chance if the null hypothesis is true. If the value of P is very small (conventionally less than 0.05) then the null hypothesis is rejected, the original positive hypothesis is accepted and the stated effect is said to be significant.

In two-way tables, "obs" means observed or actual values, whereas "exp" means expected values. We describe here how these expected values are calculated.

Chi-squared tests have been used throughout on two-way tables, but they have been used in two ways to test two different features of the data. For example, in studying the contingency table for seating position x year, one hypothesis is that these two factors are independent. This means that the ratio of casualties between year one and year two is not influenced by seating position. In this case, the expected value (exp) is calculated by multiplying together the two marginal totals and dividing by the gross total.

Most of the data are counts: numbers of casualties. When we compare counts we usually assume that they are random samples from Poisson distributions. To make tests of comparisons we need to know the variability of the underlying distributions, expressed as a standard deviation. With a purely Poisson distribution this is easy because a good estimate of the standard deviation is the square root of the observed count. If the count is more than about 30 the distribution approximates to a normal distribution. Using the properties of the normal distribution and the estimated standard deviations we can compute confidence intervals for the means of the underlying distribution.

If, for two counts to be compared, the confidence intervals do not overlap we can infer, with a stated significance level, that the two counts do not come from the same distribution. This is usually stated in terms of the probability (P) that such a large difference would have occurred between two sample counts from the same distribution. The smaller the value of P, the greater the significance.

However, Mr. Peter Scott, of the Transport and Road Research Laboratory, has told us of work which showed that casualty counts should not be regarded as purely Poisson counts and that assumption leads to gross underestimates of the standard deviation. Hutchinson and Mayne (3) show that for counts up to about 100 the variability is about that predicted by the Poisson distribution. For larger counts they recommend using the estimate:

$$\text{Sd} = \text{square root of } (\text{mean} + 0.0036\ \text{mean}^2)$$

Extending this to the use of the chi-squared test of independence in two-way tables they recommend that instead of

$$X^2 = \frac{(O - E)^2}{E}$$

the quantity

$$Y^2 = \frac{(O - E)^2}{(E + 0.0036\ E^2)}$$

should be used instead

Their recommendation for estimating standard deviation leads to very large values, which seem quite unrealistic, for large counts such as the 8237 total casualties in year one.

A more realistic figure was estimated by using their formula to calculate the variance (Sd^2) for each of the 14 hospitals in turn; adding them together to give a gross value of variance for all the hospitals; and taking the square root. This result is 159 which is 1.75 times the pure Poisson estimate of 91. Since 8232 is the largest count appearing anywhere and it would be difficult to repeat the exercise on the separate 14 hospital counts for every question that requires statistical analysis, we have used 1.75 as a multiplying factor to give an upper bound of estimates standard deviation for all the other counts.

Also, where two-way tables contain large counts (generally larger than 100) we have used their modified formula for the test statistic. Since the cell entries in these tables are aggregates of counts from several hospitals, we have again taken 1.75 as a multiplying factor for the denominator in the chi-squared calculation. Thus we have used:

$$Y^2 = \frac{(O - E)^2}{1.75\,E}$$

These are called the HM (Hutchinson Mayne) estimates in the text.

A test statistic to compare two counts, which is equivalent to asking if the two confidence intervals overlap or not is

$$Z = \frac{N_1 - N_2}{N_1^2 + N_2^2}$$

This can be tested as an approximation to a standard normal variate. In this study, where N_1 and N_2 are large and are aggregates of counts from several hospitals, we have divided Z by 1.75 before referring to the standard normal table. We call this the HM adjusted test statistic.

The HM adjustment guards against type I error: the rejection of the null hypothesis when it is true. In other words it guards against attaching significance to effects which may be spurious.

We have used the same cautious approach to tables which we have analysed with log-linear models.

We will now proceed to examine in detail each of the predictions set out in our original hypotheses. These hypotheses will be found in Section 5.6. In each of the sections which follows we will start with one or more predictions derived from these hypotheses, develop the statistical argument and conclude with an inference.

9.1 Total Casualties

9.1.1 *Prediction* (1) A Reduction in the Number of Patients — Outpatients, Inpatients and Deaths — (see Section 5.6)

The total number reported in all 14 hospitals in year one was 8237 (see Table 14). The total number reported to all 14 hospitals in year two was 6977. The HM adjusted test statistic is 5.83 so the null hypothesis that there has been no change in the casualty rate from the first to the second year can therefore be rejected. The probability that the apparent change is simply due to random variation from year to year is $P < 0.001$. The corresponding figures after excluding the uninjured and those dead on arrival were 7626 and 6393. The

HM adjusted test statistic is 5.95 which is highly significant ($P < 0.001$).
Inference: There has been a reduction in total casualties of 15 per cent ($P < 0.001$).

9.1.2 The Changes for all 14 Hospitals — Table 1

These can be tested by a paired t-test. The t-value is 3.46 with 13 degrees of freedom. The null hypothesis that there is generally no change for individual hospitals between the two years may therefore be dismissed ($P < 0.001$).
Inference: The distribution of reduction for all 14 hospitals is significantly greater than zero ($P < 0.001$).

9.1.3 Is the reduction associated with Seating Position?

If so, are the general conclusions influenced by the quality of data in terms of knowledge of seating position and belted status?

(a) The following table is of numbers of casualties for whom seating position and belted status were known, also excluding the uninjured and those dead on arrival.

		Year One		Year Two		Y1:Y2
Drivers	obs	3538		3052		
	exp		3585		3005	1.16
FSP	obs	1880		1366		
	exp		1766		1480	1.38
RSP	obs	1073		1023		
	exp		1140		956	1.05
Totals		6491		5441		1.19

The HM adjusted chi-squared values is 14.99 with 2 df. This is highly significant ($P < 0.001$). We reject the null hypothesis of independence of seating position and year. The major effect is among front seat passengers.
Inference: The change in the numbers of casualties is strongly associated with seating position.

(b) The following table is of numbers of casualties for whom seating position was known, but for some of whom belted status was not known, after excluding the uninjured and those dead on arrival.

		Year One		Year Two		Y1:Y2
Drivers	obs	4094		3565		
	exp		4144		3515	1.15
FSP	obs	2062		1515		
	exp		1936		1643	1.36
RSP	obs	1167		1131		
	exp		1243		1055	1.03
Totals		7323		6211		1.18

The HM adjusted chi-squared value is 16.72 with 2 df. This is highly significant ($P < 0.001$). The inference is as for (a).

(c) The following table is of numbers of casualties, for some of whom seating position and for some of whom belted status was not known, after excluding the uninjured and those dead on arrival.

		Year One		Year Two		Y1:Y2
Drivers	obs	4094		3565		
	exp		4166		3493	1.15
FSP	obs	2062		1517		
	exp		1947		1632	1.36
RSP	obs	1167		1131		
	exp		1250		1048	1.03
Not Known	obs	303		180		
	exp		263		220	1.68
Totals		7626		6393		1.19

The HM adjusted chi-squared value is 24.75 with 3 df. This is highly significant ($P<0.001$). The greatest relative improvement is among those for whom seating position is not known.

The general conclusion is that the relatively small numbers for whom full information is not available make no difference to the inferences.

We believe it is reasonable for all the following analyses, to restrict our attention to those casualties for whom seating position and belted status were known.

9.1.4 Was the reduction in the number of patients caused by the increased use of seat belts?

The reported casualties for whom both the seating position and the belted status were known were:

	Year One				Year Two			
	Belt		No Belt		Belt		No Belt	
Driver	944		2594		2816		236	
		(69.4%)		(63.9%)		(69.2%)		(67.4%)
FSP	416		1464		1252		114	

The data for the rear seat passengers are excluded from this analysis because their inclusion would complicate the model out of proportion to the extra numbers. The analysis was done by fitting a log-linear model and testing the main effects and first order interactions.

The analysis tests whether or not interactions between factors have any significant effect, accepting first that the main factors (year, position, belt) do have significant effects. We know that analysis for each in turn shows it to be

effective. The important question is: do they influence each other or are the effects independent?
The results show:

(a) Belt x year is a significant interaction ($P<0.001$). Thus the proportion of casualties who were wearing belts has changed from year one to year two.

(b) Position x year is not a significant interaction. The distribution of position, among casualties, has not changed from year one to year two.

(c) Position x belt is a significant interaction ($P<0.001$). Thus the distribution of the seating positions of casualties has been influenced by the wearing of belts.

The wearing of belts is associated with a greater proportion of casualties among drivers than among front seat passengers. This suggests that belts are more effective in preventing injury to front seat passengers. Alternatively, it may be that belts are worn less by front seat passengers than by drivers. However, Department of Transport counts show that the wearing rates are virtually the same for front seat passengers as for drivers.

Looking only at marginal results it is not possible to state whether the change in distribution of casualties according to seat position from year one to year two is simply a chronological effect or if it is caused by the use of belts.

The fact that the position x year interaction is not significant, but the belt x year and the belt x position interactions are significant, supports the belief that reduction in the number of casualties can be attributed to the use of belts rather than any other factor associated with time. Although these interactions are needed in the model, the main effects (belting, year and seating position) are still separately significant. Thus there are both interactive and dependent effects.

Inference: The change in the number of casualties and the change in distribution relative to seating position are both strongly associated with the wearing of belts and are not merely caused by other time-related but unrecorded factors.

9.2 Outpatient casualties

Has there been a reduction in the number of outpatient casualties?

9.2.1 Totals

The total number of outpatients (Table 20) in one year was 5759 and in year two 5035. The HM adjusted test statistic is 3.98 so the null hypothesis can be rejected ($P<0.001$).

Inference: There has been a reduction in outpatient casualties of 12.6 per cent.

9.2.2 Seating positions

The figures for seating positions for outpatient casualties were:

	Driver	FSP	RSP
Year 1 obs	3139	1604	956
exp	3237	1524	998
Year 2 obs	2868	1253	914
exp	2830	1333	872
Ratio Y1:Y2	1.115	1.280	1.046

The HM adjusted chi-squared value is 7.78 with two degrees of freedom. The null hypothesis that the counts for the two years are independent of the seating positions is therefore rejected (P<0.05).

Inference: The reduction in outpatient casualties depends on seating position. The differences in the changes between the seating positions is shown by the ratios. The greatest improvement is for front seat passengers, the least is for rear seat passengers.

9.3 Inpatient casualties

Has there been a reduction in the number of inpatient casualties?

9.3.1 Totals

The total number of admitted patients (Table 20), including both discharged alive and died in hospital, in year one was 1564. The HM adjusted test statistic is 4.21 so the null hypothesis can be rejected (P<0.001).

Inference: There has been a reduction in inpatient casualties (24.7 per cent).

9.3.2 Seating positions

The figure for seating positions for admitted casualties were:

	Driver	FSP	RSP
Year 1 obs	895	458	231
exp	908	412	244
Year 2 obs	697	264	217
exp	684	310	184
Ratio Y1:Y2	1.284	1.735	0.972

The HM adjusted chi-squared value is 13.1 with two degrees of freedom. The null hypothesis that the counts for the two years are independent of the seating positions is therefore rejected (P<0.01)

Inference: The reduction of inpatient casualties depends on seating position. The difference in the changes between the seating positions is shown by the ratios. The greatest improvement is for the front seat passengers, the least is for the rear seat passengers.

9.4 Bed-days

Prediction (2):
A reduction in the number of bed-days (see Section 5.6).

9.4.1 Totals

The total number of bed-days (Table 21) in year one was 14844 and in year two was 11109. The HM adjusted test statistic is 13.2 so the null hypothesis can be rejected (P<0.001).

Inference: There has been a reduction in the number of bed-days occupied by inpatient casualties of 25 per cent. The mean duration of stay for those who were admitted was 9.5 days in year one and 9.4 days in year two, not a significant change.

9.4.2 Seating positions

The figures for seating positions for numbers of bed-days were:

	Driver	FSP	RSP
Year 1 obs	8814	4272	1758
exp	8741	4041	2062
Year 2 obs	6468	2794	1847
exp	6541	3025	1543
Ratio Y1:Y2	1.363	1.529	0.952

The HM adjusted chi-squared value is 78.2 with two degrees of freedom. The null hypothesis that the numbers of bed-days for the two years are independent of seating position is therefore rejected (P<0.001).

Inference: The reduction in bed-days depends on seating position. The greatest reduction is for front seat passengers (34.6 per cent).

9.4.3 Distribution

Has there been any change in the distribution of numbers of days in hospital? The following totals are taken from Table 21.

Days in hospital		Year one	Year two	Ratio Y1:Y2
0-2	obs	880	626	1.406
	exp	859	647	
3-14	obs	440	381	1.155
	exp	468	353	
15+	obs	244	170	1.435
	exp	236	178	

The computed chi-squared value is 3.3 with two degrees of freedom. The null hypothesis that distribution of numbers of days in hospital has not changed from year one to year two cannot be rejected. The evidence is not strong enough to say that there has been a change in the distribution.

These counts may be converted to proportions by dividing by the total number of admitted patients in the corresponding year (1564 and 1178) so as to identify the change in distribution.

Days in hospital	Year one	Year two	Ratio Y1:Y2
0-2	0.563	0.531	1.060
3-14	0.281	0.323	0.870
15+	0.156	0.144	1.083

This suggests that while there have been relative falls in the long and short term patients, there has been a relative increase in the medium term patients. However, this should not be regarded as a proven conclusion.

9.5 Severity of injuries

Prediction (3): A reduction in the average severity of injuries

Prediction (4): A reduction in the number of severe injuries

Prediction (15): Front seat occupants who are belted will have lower mean severity scores in the first year than the second.

Prediction (16): Front seat occupants who are unbelted will have higher mean severity scores in the second year than in the first.

Prediction (17): Late night and early morning front seat occupants will have lower rates of belt wearing and higher mean severity scores than at other times of the day.

Has the average (mean) severity of injuries fallen and, if so, is the change associated with seating position and the use of belts?

There are two general measures of severity which are described in other chapters. There are MAIS (maximum abbreviated injury scale) and ISS (injury severity score). The question is tackled statistically by references to only ISS.

9.5.1 Injury severity score

The following table is of the mean values of ISS computed over all casualties for whom both seating position and belted status are known.

	Year One		Year Two		Two Years Combined		
	Belted	Unbelted	Belted	Unbelted	Belted	Unbelted	Combined
Drivers	2.6144	3.114	2.6776	4.6483	2.6617	3.2396	2.9099
FSP	2.7428	2.9324	2.5208	4.1140	2.5761	3.0177	2.7908
RSP	1.5000	2.4816	1.5588	2.7351	1.5435	3.0639	2.5806
						All Casualties	2.8196

Analysis of variance for these casualties is:

Source of variation		Sum of squares	df	mean squares	F	Significance as a P value
Main Effects						
	Position	668.9	2	334.4	19.46	0.001
	Belts	868.4	1	868.4	50.52	0.001
	Year	176.0	1	176.0	10.24	0.001
Interactions						
	Position and belt	34.8	2	17.4	1.01	0.363
	Position and year	282.2	2	141.1	8.21	0.001
	Belt and year	502.2	1	502.2	29.28	0.001
Residual		204923	11922	17.19		
Total		206543	11931	17.31		

All three main effects and the two interactions, position and year and belt and year are highly significant. The interaction position and belt is not significant.

The linear model for means, using the significant terms, is:

$$y = 2.585 + \left\{\begin{array}{r} 0 \\ -0.025 \\ -0.873 \end{array}\right\}\begin{array}{l} \text{D} \\ \text{FSP} \\ \text{RSP} \end{array} + \left\{\begin{array}{c} 0 \\ 0.288 \end{array}\right\}\begin{array}{l} \text{Y1} \\ \text{Y2} \end{array} + \left\{\begin{array}{c} 0 \\ 0.556 \end{array}\right\}\begin{array}{l} \text{B} \\ \text{UB} \end{array}$$

$$+ \begin{array}{cl} \left\{\begin{array}{cr} 0 & 0 \\ 0 & -0.330 \\ 0 & -0.644 \end{array}\right\} & \begin{array}{l} \text{D} \\ \text{FSP} \\ \text{RSP} \end{array} \\ \begin{array}{cc} \text{Y1} & \text{Y2} \end{array} & \end{array} + \begin{array}{cl} \left\{\begin{array}{cc} 0 & 0 \\ 0 & 0 \end{array}\right\} & \begin{array}{l} \text{Y1} \\ \text{Y2} \end{array} \\ \begin{array}{cc} \text{B} & \text{UB} \end{array} & \end{array}$$

The interpretation is that the RSP have a significantly lower score than the FSP; the unbelted have a significantly higher score than the belted; and the year two score is significantly higher than year one, although relatively much less than either of the two main effects.

The most significant interaction shows that the score for unbelted casualties is much higher in year two than in year one. This suggests that those car occupants who do not wear belts in spite of legislation have sustained more severe injuries than the prelegislation unbelted occupants. This was predicted (see hypothesis 16 in Section 4.6). Overall the general mean for year two is 0.288 higher than for year one.

For each of these the mean severity of casualties (for whom seating position and belted status were known) has not fallen, in fact there has been a slight increase. It should be remembered, however, that the total number of casualties is 15 per cent less, so that if the same numbers of people were included there would be 15 per cent in the second year with zero severity. This would change the situation so that it could be claimed that the mean severity had fallen.

9.5.2 Time of day and severity

The following is a table of mean ISS for *all* casualties at different times of day. The numbers of casualties are in brackets.

Time	Year One	Year Two
23.00 to 2.59	3.4219 (1223)	3.5124 (931)
3.00 to 7.59	3.4388 (392)	3.5205 (317)
8.00 to 12.59	2.6003 (1421)	2.5681 (1241)
13.00 to 17.59	2.7814 (1857)	2.7332 (1574)
18.00 to 22.59	2.7289 (1671)	2.6279 (1403)
24 hours	2.8874 (6564)	2.8471 (5466)

Standard Error of Means: 0.392

Analysis of Variance:

Source of variation	Sum of squares	df	Mean squares	F value	P value
Main effects					
year	2.002	1	2.002	0.10	0.74
time	1374.9	4	343.7	18.69	< 0.001
Interaction					
year x time	13.932	4	3.48	0.183	0.94
Residual	221002.12	12020	18.386		
Total	222395.81	12029	18.488		

The analysis shows that there is no significant difference in the distribution between years, but that the differences between the time periods are highly significant. Late night and early morning casualties have higher mean severity scores than those of other time periods.

Prediction (17): Late night and early morning front seat occupants will have lower rates of belt wearing and higher mean severity scores than at other times of the day. The differences shown above between time periods are almost exactly the same as those for FSO only as seen in Table 19. The estimated standard error of means of 0.039 may be used to test differences between ISS means. These differences are so great relative to the standard error that it is clear that prediction 17 is fulfilled.

There has apparently been a small change in mean severities between the years in the late night and early morning but these have remained, together, the period of greatest mean severity.

There is no significant difference in the overall mean severities of the two years.

9.5.3 Numbers of severe injuries

Prediction (4): A reduction in the number of severe injuries. The following data taken from Table 24 are the numbers of injuries with AIS of 3 or greater.

		Year One		Year Two	
Drivers	obs	405		326	
	exp		400		331
FSP	obs	168		128	
	exp		162		134
RSP	obs	75		81	
	exp		85		71
Totals		648		535	

Inference: There has been a significant reduction in the number of severe injuries ($P < 0.01$).

The chi-squared value is 3.41 with 3 df. This is not significant.

Inference: The distribution of the number of severe injuries according to seating position has not changed from year one to year two.

9.5.4 Conclusions

A notable inference is that the mean values are greater for the second year than for the first. Another is that the use of belts has a major effect quite distinct from the time effect. A third is that the severity for unbelted increases greatly in year two.

The first of these is at first surprising until it is remembered that the total number of casualties diminished by 15 per cent. If we adjusted the means of severity scores in the second year by supposing there were as many casualties in each seating position but that the difference had zero severities, then the mean values would be much less for the second year than for the first.

The conclusion is nevertheless that although there has been a 15% reduction in casualties, the average severity has not changed except among the unbelted, where it has increased.

9.6 Facial injuries

Prediction (9): A reduction in minor injuries to the face

9.6.1 Facial abrasions

Has there been a change in the distribution and number of casualties with facial abrasions?

The following data was taken from Table 45.

		Year One	Year Two	Ratio Y1:Y2
Drivers	obs	317	163	1.94
	exp	308	172	
FSP	obs	165	65	2.54
	exp	148	82	
RSP	obs	105	99	1.06
	exp	131	73	
Totals		587	327	1.80

9.6.1.1 Totals

The total number of casualties with facial abrasions has fallen very significantly ($P < 0.001$).

9.6.1.2 Independence

The expected values in the table are calculated according to the null hypothesis of independence between seating position and year. The HM adjusted chi-squared value is 11.9 with 2 df. This is significant ($P < 0.01$).

9.6.1.3 Seating

It is clear that there has been a large fall in the numbers of front seat occupants (both drivers and passengers) with facial abrasions, whereas there has been hardly any change in the numbers of RSPs.

9.6.1.4 Belts

The following table shows the numbers of patients with facial abrasions for whom both seating position and belted status were known.

	Year One		Year Two	
	Belted	Unbelted	Belted	Unbelted
Drivers	57	225	130	16
FSP	19	134	52	8
RSP	5	95	3	86

A log-linear model fits well, provided all three first order interactions are included. It is clear from this and from the data that the use of belts has had a major effect except among rear seat passengers, few of whom have the opportunity to use belts.

Inference: The number of casualties with facial abrasions has fallen by 60 per cent. This is markedly attributable to front seat passengers with negligible contribution from rear seat passengers ($P<0.01$).

9.6.2 Facial contusions

Has there been a change in the distribution and numbers of casualties with facial contusions?

The following data are taken from Table 47.

		Year one	Year two	Ratio Y1:Y2
Drivers	obs	662	292	2.27
	exp	662	292	
FSP	obs	387	121	3.20
	exp	352	156	
RSP	obs	237	155	1.53
	exp	272	120	
Totals		1286	568	2.26

9.6.2.1 Totals

The total number of casualties with facial contusions has fallen very significantly (P<0.001).

9.6.2.2 Independence

The expected values in the table are calculated according to the null hypothesis of independence between seating position and year. The HM adjusted chi-squared value is 14.7 with 2 df. This is highly significant (P<0.001).

Although there has been a large reduction in drivers with facial contusions, the fall corresponds to the marginal totals. The fall has been less than expected, assuming independence, among RSPs and much larger than expected among FSPs.

9.6.2.3 Seating

Using the year one values as expected values for year two, there has been a significant fall for each of the seating positions. Even for RSP's the significance is highly significant (P<0.001).

9.6.2.4 Belts

The following table shows the number of patients with facial contusions for whom the seating position and belted status were known.

	Year One		Year Two	
	Belted	Unbelted	Belted	Unbelted
Drivers	122	458	235	29
FSP	49	303	89	15
RSP	1	224	6	137

A log-linear model fits well provided all those first order interactions are included. The same remarks apply as to the analysis of facial abrasions.

Inference: The number of casualties with facial contusions has fallen by 56 per cent. Although this is mainly attributable to front seat passengers and drivers, there is a contribution from the rear seat passengers (P<0.001).

9.6.3 Facial wounds

9.6.3.1 Totals

Has there been a change in the distribution and numbers of casualties with facial wounds?

The following data are taken from Table 48.

		Year One		Year Two		Ratio Y1:Y2
Drivers	obs	1101		617		1.78
	exp		1111		607	
FSP	obs	553		206		2.68
	exp		491		268	
RSP	obs	233		208		1.14
	exp		285		156	
Totals		1887		1031		1.83

The total number of casualties with facial wounds has fallen very significantly (P<0.001).

9.6.3.2 Independence

The expected values in the table are calculated according to the null hypothesis of independence between seating position and year. The HM adjusted chi-square value is 28.3 with 2 df. This is highly significant. The interpretation is the same as for 9.6.2.2.

9.6.3.3 Seating

The changes are most associated with the front seat occupants. The small reduction in RSP casualties is not statistically significant.

9.6.3.4 Belts

The following table shows the numbers of patients with facial wounds for whom both seating position and belted status were known.

	Year One		Year Two	
	Belted	Unbelted	Belted	Unbelted
Drivers	140	657	375	69
FSP	38	405	125	26
RSP	1	174	1	150

A log-linear model fits well provided all three first order interactions are included. The same remarks apply as in 9.6.1.4.

Inference: The number of casualties with facial wounds has fallen by 48 per cent. This is mainly attributable to front seat passengers and drivers with a small contribution from the rear seat passengers (P<0.001).

9.6.4 Eye injuries

The following data are taken from Table 26.

	Year One	Year Two	Y1:Y2
Drivers	98	61	1.61
FSP	53	32	1.66
RSP	14	16	
Total	165	109	

Inference: There has been a significant reduction in the numbers of casualties with eye injuries (P<0.01). The number of RSPs with eye injuries has not changed significantly. The reduction among front seat occupants is independent of seating position (driver or FSP).

9.6.5 Conclusions

The numbers of casualties with facial injuries fell greatly from year one to year two and this was strongly associated with the wearing of belts. Rear seat passengers, few of whom wear belts, did not show the same reduction as front seat occupants for abrasions and wounds, but they had an unexpectedly large decrease of contusions. This suggests that for some reason the restraint of front seat occupants reduced the risk of impact with hard objects by rear seat passengers.

9.7 Facial fractures

Prediction (10): A reduction in facial fractures

Has there been a change in the distribution and numbers of facial fractures and dislocations?

The following data are from Table 39.

		Year One		Year Two		Ratio Y1:Y2
Drivers	obs	134		147		0.91
	exp		146		135	
FSP	obs	59		32		1.84
	exp		47		44	
RSP	obs	36		33		1.09
	exp		36		33	

The chi-squared value is 8.1 with two degrees of freedom. This is statistically significant (P<0.05). The major contribution is the large proportionate change in FSPs with facial injuries.

However, the total number of casualties with facial fractures has not changed significantly.

Inference: There has been a small but statistically insignificant fall in the number of casualties with facial fractures. However, there has been a large proportionate fall in the front seat passengers with facial fractures (P<0.05).

9.8 Brain injuries

Prediction (7): A reduction in brain injuries.

Has there been any change in the distribution and numbers of brain injuries?

9.8.1 All Brain injuries

The numbers of casualties with brain injuries taken from Table 28 were:

		Year One		Year Two		Ratio Y1:Y2
Drivers	obs	638		445		1.43
	exp		652		431	
FSP	obs	318		137		2.32
	exp		274		181	
RSP	obs	164		158		1,04
	exp		194		128	

There has been a significant fall in the total number of casualties with brain injuries (P<0.001).

The chi-squared value is 30.13 with two degrees of freedom. This is highly significant (P<0.001) and there is a clear dependence between seating position and year. The greatest change has been with FSP.

9.8.2 Major brain injuries

		Year One		Year Two		Ratio Y1:Y2
Drivers	obs	32		46		0.70
	exp		38		40	
FSP	obs	22		13		1.69
	exp		17		18	
RSP	obs	13		13		1.00
	exp		13		13	

There has not been a significant change in the total number of casualties with major brain injuries.

The chi-squared value is 4.65 with two degrees of freedom. This is hardly significant (P = 0.10) but even with these small numbers it is clear that the major effect is again with FSP. There is an increase among drivers which is not statistically significant.

There has been no change among RSPs. Omitting these, the chi-squared value for the 2 × 2 table is 4.61 with 1 df. This is significant ($P<0.05$) so that the null hypothesis of independence may be rejected and we can infer that there has been a real increase in major brain injuries among drivers and a corresponding decrease among FSPs.

Inference: The number of casualties with brain injuries has fallen by 34 per cent. This is related to seating position ($P<0.001$) and is mainly attributable to front seat passengers.

There has not been a significant change in the total number of casualties with major brain injuries. There has, however, been a change in the distribution relative to seating position ($P<0.05$): an increase among drivers* and a decrease among front seat passengers.

9.9 Skull fractures

Prediction (12): A reduction in skull fractures.

Has there been a change in the distribution and numbers of skull fractures? The following data was taken from Table 41.

		Year One		Year Two		Ratio Y1:Y2
Drivers	obs	38		39		0.97
	exp		42		35	
FSP	obs	17		5		3.40
	exp		12		10	
RSP	obs	14		13		1.08
	exp		15		12	
Totals		69		57		1.21

9.9.1 Total

The total number of casualties with skull fractures has not changed significantly.

9.9.2 Independence

The expected values in the table are calculated according to the null hypothesis of independence between seating position and year. The chi-squared value is 5.5 with two degrees of freedom. This is statistically significant ($P<0.05$).

9.9.3 Seating

Using year one values as the expected values for year two according to the null hypothesis of no change for any of the seating positions, the total chi-squared value is 8.57 with 3 df. This is significant ($P<0.05$). The major contribution is by the change in FSPs: chi-squared = 8.47 with 1 df ($P<0.01$).

9.9.4 Belts

The following table shows the number of patients with skull fractures for which both seating position and belted status were known.

	Year One		Year Two	
	Belted	Unbelted	Belted	Unbelted
Drivers	4	24	26	5
FSP	1	16	4	1
RSP	1	11	0	12

A log-linear model with a good fit included the three main effects and the two interactions position by belt and year by belt. This means that there is a relationship between belting and position, apart from the year, and the effect of belting has changed from year one to year two.

This means that the use of belts is associated with the improvement for FSPs from year one to year two, but they are not similarly protecting drivers.

9.10 Major brain injuries or skull fractures

The data for major brain injuries or skull fractures have been combined into the following table. It is a count of those patients who have either one or the other or both types of injury, and whose seating position and belted status are known.

		Year One		Year Two	
		Belted	Unbelted	Belted	Unbelted
Drivers		6	38	42	12
FSP		5	24	11	3
RSP		1	15	0	19
Totals	obs	12	77	53	34
	exp	33	56	32	55
Totals		89		87	

There is a significant difference in the totals between the two years.

Considering the 2 x 2 table of belted a year, the chi-squared value is 42.5 with 1 df which is highly significant ($P < 0.001$).

		Year One		Year Two		Ratio Y1:Y2
Drivers	obs	44		54		0.81
	exp		50		48	
FSP	obs	29		14		2.07
	exp		22		21	
RSP	obs	16		19		0.84
	exp		18		17	

Considering the 3 x 2 table of seating position and year, the chi-squared value is 6.49 with 2 df which is significant ($P < 0.05$).

The inferences are that although there has not been a change in the overall incidence, there has been a change in the distribution according to seating position with a large decline among front seat passengers and a slight increase among drivers. There has also been a slight increase among rear seat passengers.

The changes are strongly associated with the use of seat belts.

Inference: There has not been a significant change in the number of casualties with skull fractures. However, there has been a large proportionate fall in the front seat passengers with skull fractures ($P < 0.05$).

There has been a change in the effect of belting from year one to year two. The use of belts is associated with the improvement for front seat passengers but not for drivers.

Casualties who had either major brain injury or skull fracture or both also showed a change in the distribution according to seating position with a large relative decline among front seat passengers and slight increases among drivers and rear seat passengers. These changes are strongly associated with the use of seat belts.

9.11 Sprained necks

Prediction (12): An increase in sprained necks.

Has there been a change in the distribution and numbers of sprained necks?

The following data are taken from Table 43.

		Year One		Year Two		Ratio Y1:Y2
Drivers	obs	736		901		0.817
	exp		749		888	
FSP	obs	320		346		0.925
	exp		305		361	
RSP	obs	81		102		0.794
	exp		84		99	
Totals		1137		1349		

There has been a significant increase in the number of casualties with sprained necks ($P < 0.01$) using the HM adjusted test statistic.

9.11.1 Independence

The chi-squared value is 1.99 with 2 df. This is not significant. The increase is independent of seating position.

9.11.2 Seating position

Using year one values as expected values for year two, the total HM adjusted chi-squared value is 25.4, partitioned as drivers 21.1; FSP 1.2; RSP 3.1. Thus the most significant effect is among drivers. However, there is an expected but insignificant increase in sprained necks among RSPs, for which we should seek further evidence and an explanation.

9.11.3 Belts

The following table shows the numbers of patients with sprained necks for which both seating position and belted status were known.

	Year One		Year Two	
	Belted	Unbelted	Belted	Unbelted
Drivers	265	389	766	31
FSP	97	201	305	16
RSP	0	76	3	94

The log-linear fit requires all three first order interactions but then it is almost a perfect fit. There have been large reductions in the number of unbelted front seat casualties and large increases in the belted. However, there has been an increase of 24 per cent in the rear seat unbelted casualties. This may partly be attributed to the increase in traffic and possibly accidents (see Section 5.2). It may be partly due to some passengers preferring to sit in rear seats rather than using belts in front seats. This is not likely because the same change is not shown in other injuries. It may also be because more sprained necks are reported or diagnosed.

Inference: There has been a significant increase in the number of casualties with sprained necks ($P < 0.01$). This is particularly attributable to drivers.

9.12 Fractures of the sternum

Prediction (13): An increase in fractures of the sternum.

9.12.1 Numbers and distribution

Has there been a change in the number and distribution of casualties with fractured sternum?

The following data are taken from Table 40.

		Year One		Year Two		Ratio Y1:Y2
Drivers	obs	24		48		0.50
	exp		23		49	
FSP	obs	9		23		0.39
	exp		10		22	
RSP	obs	3		4		
	exp		2		5	
Totals		36		75		

There has been a significant increase in the number of casualties with fractured sternums ($P < 0.001$).

9.12.2 Independence

The chi-squared value is 0.64 with 2 df. There is insufficient evidence to dismiss the null hypothesis of independence.

The figures for RSPs are so small that they may be disregarded. Analysis of the 2 x 2 table still supports the null hypothesis of independence.

9.12.3 Seating position

Using year one values as expected values for year two. the total chi-squared value is 45.8 (ignoring RSP) partitioned as: driver 24.0; FSP 21.8. Thus there is no significant difference between the changes for the two positions.

9.12.4 Belts

The following table shows the number of patients with fractured sternums for which both seating position and belted status were known but excluding rear seat passengers.

	Year One		Year Two	
	Belted	Unbelted	Belted	Unbelted
Drivers	7	16	44	2
FSP	5	4	21	1

A good log-linear fit is obtained with the three main effects and the single first-order interaction belt x year. The other interactions do not contribute. The main effect of belt and the interaction were needed for a good fit. A good log-linear fit is obtained with the three main effects and the single first-order interaction belt x year. The other interactions do not contribute. The main effect of belt and the interaction were needed for a good fit. The interaction term is a consequence of the simultaneous change in the casualty frequency and the belt wearing rate and does not contribute to the argument that wearing of belts contributes to the change in casualties. The important point of this analysis is that a significant belt effect is needed as a *main* effect in the model *as well as* a year effect. The inference is that changes are attributable in part to the use of belts (P < 0.001).

Inference: There has been a significant increase of 108 per cent in the incidence of fractured sternums (P < 0.05). There is no evidence that this increase is associated with seating position. The changes are associated with the use of seat belts (P < 0.001).

9.13 Lung injuries

Prediction (11): A reduction in injuries to the lungs

9.13.1 Numbers and Distributions

Has there been a change in the distribution and numbers of lung injuries?

	Year One		Year Two	
	Belted	Unbelted	Belted	Unbelted
Drivers	11	38	26	9
FSP	3	15	7	1
RSP	0	6	0	1

First, disregard the small figures for RSP and consider only the change from year one to year two without including belted status.

		Year One		Year Two		Ratio Y1: Y2
Drivers	obs	49		35		1.4
	exp		51		33	
FSP	obs	18		8		2.25
	exp		16		10	
Totals		67		43		

There has been a significant decrease from year one to year two (P < 0.05).

9.13.2 Independence

The chi-squared value is 0.99 with one degree of freedom. This is not significant.

9.13.3 Seating position

The reduction for FSPs is relatively greater than for drivers.

9.13.4 Belts

A log-linear model with a good fit included all three main effects but only the first order interaction belt x year. This confirms that the effects of seating position and year were independent but that there is an association between belting and year.

This is again confirmed by the following table:

		Year One	Year Two	Ratio Y1:Y2
Belted	obs	14	33	0.42
	exp	29	18	
Unbelted	obs	59	11	5.36
	exp	44	26	

The chi-squared value is 35.6 with one df. This is highly significant ($P < 0.001$).

9.13.5 Relative risk of sustaining lung injury when belted and unbelted

About 35% of FSOs in the community wore belts in year one. About 95 per cent wore belts in year two (See Table 18).

Consider year one

Let N = total number of people at risk of injury,

an unknown number.

The probability of being injured, given that a person is belted,

$$P(I|B) = \frac{P\,(I \cap B)}{P\,(B)}$$

where $P\,(I\,B)$ is the probability of being both injured and belted and $P\,(B)$ is the probability of being belted.

From the table, $P\,(I \cap B) = 14/N$

(let us assume that $P\,(B) = 0.35$ (35 per cent) (See Table 18)

so

$$P_1(I|B) = \frac{14}{0.35\ N}$$ where the suffix 1 refers to year one

Now, assume that there are the same number (N) of people at risk of injury in year two as in year one (Table 2, which shows traffic volume suggests this is a fair approximation).

Then, for year two $P_2(I|B) = \dfrac{33}{0.95N}$

since there were 33 belted casualties with lung injuries and the observed wearing rate is 0.95 (see Table 18). The suffix 2 refers to year two.

Now, apply the same reasoning for the unbelted casualties. Denote "not belted" by $\bar{B}$.

$$P_1(I|\bar{B}) = \frac{59/N}{1\text{–}0.35} = \frac{59}{0.65N}$$

$$P_2(I|\bar{B}) = \frac{11/N}{1-0.95} = \frac{11}{0.05N}$$

To answer the question as to the relative rates of a casualty suffering lung injury according to whether or not he was belted, we arrange the conditional probabilities as follows:

	Year One	Year Two	Mean of Year 1 and Year 2
$P\ (I\|\bar{B})$	$\frac{14}{0.35N}$	$\frac{33}{0.95N}$	$\frac{74.7}{N}$
$P\ (I\|\bar{B})$	$\frac{59}{0.65N}$	$\frac{11}{0.05N}$	$\frac{310.8}{N}$
Relative Risk $\frac{P\ (I\|\bar{B})}{P\ (I\|\bar{B})}$	2.27	6.33	4.16

It must be admitted that the values of 35% and 95% for the belting rates of front seat occupants in the community are only very rough approximations (see Table 18). Also the argument is based on the assumption that equal numbers were at risk in the two years. However, this assumption has run through much of the analysis, and has been argued in Chapter 5, Sections 5.2, 5.3 and 5.4.

The change in the relative risk of suffering a lung injury in year one and year two are related to the changes in mean severity scores of the belted and the unbelted in the two years as already demonstrated in Section 9.6.1. However, it is not the exact amount of the relative risk which is important, but the fact that for all three periods (first year, second year and both years), the risk of sustaining a lung injury is much higher for the unbelted than the belted.

Inference: The decrease in casualties with lung injuries in the second year is related to the higher rates of belt wearing.

9.14 Belted rate by time of day

Prediction (17): A lower rate of belting among front seat occupants in the period "late night and early morning" compared with other times of the day.

Is the belting rate lower among front seat occupants in the period 23.00–02.59 hours compared with other periods?

The following data are taken from Table 19.

	First Year FSO		Second Year FSO	
	Number Belted	% Belted	Number Belted	% Belted
23.0002.59	152	17.7	524	84.5
3.0022.59	1046	26.6	3080	93.5
		8.9		9.0

For year one, the chi-squared value is 25.71 with two degrees of freedom. This is statistically significant ($P < 0.001$). For year two, the chi-squared test is 56.06 with two degrees of freedom. This is statistically significant ($P < 0.001$).

Inference: the belting rate of front seat occupants between 23.00 and 02.59 was 8.9% lower than the rest of the 24 hours in the first year and 9.0% lower in the second year. The differences are highly significant ($P < 0.001$).

9.15 Multiplicity of injuries

Nothing needs to be added to what has already been said in Chapter 8, Section 8.6.

10. Conclusions

10.1 Outcome of hypotheses

In our introduction we stated the purpose of this project as being to establish sound evidence of the changes in hospital casualties among car occupants injured in road traffic accidents consequent on the introduction of compulsory seat belt legislation in the United Kingdom. We claim that this 14 hospital study extending for a year before and a year after the implementation of legislation has succeeded in establishing such evidence. The methodology was meticulous and the supervision at all stages was rigorous both where the original data were collected in the hospitals and also during data processing and analysis in Belfast. The number of patients with serious injuries in the survey are equal to 5% of such patients in the whole of Great Britain.

With such a large mass of data, we foresaw the pitfalls arising from data dredging, and apparently "proving" many changes which had only arisen because of the great variety and scope of the data. We therefore concentrated the statistical analysis on the hypotheses which had been enunciated in advance. There were in all 17 such hypotheses. Let us restate each hypothesis, and beside each state our conclusion:

(1) A reduction in the number of patients, outpatients, inpatients and deaths.

Finding:- Confirmed for total patients, outpatients and inpatients.

Total patients reduced by 14.6% from 7273 to 6213.

Outpatients reduced — drivers 10%, front seat passengers 22%.

Inpatients reduced — drivers 23%, front seat passengers 43%.

Deaths — Impossible to confirm or reject from our data.

(2) A reduction in the number of bed days.

Finding:- Confirmed. Bed days reduced, drivers 27%, front seat passengers 35%.

(3) A reduction in the average severity of injuries.

Finding:- Not confirmed by our data. The mean injury severity scores were not significantly changed except among the unbelted among whom it increased.

(4) A reduction in the number of severe injuries.

Finding:- Confirmed. Drivers 20%, front seat passengers 24%.

(5) A reduction in the multiplicity of injuries, both major and minor to front seat passengers.

Finding:- Confirmed.

(6) A lower probability of death if uninjured.

Finding:- Our data does not allow this to be confirmed or rejected.

(7) A reduction in brain injuries.

Finding:- Confirmed for a total of major and minor brain injuries. Drivers

30%, front seat passengers 57%. However, for drivers there were 44% more major head injuries.

(8) A reduction in skull fractures.

Finding:- This was not confirmed. It should be noted that there was a 71% reduction for front seat passengers but a 2.6% increase for drivers. As there were three times as many injured drivers, there was no overall reduction.

(9) A reduction in minor injuries to the face.

Finding:- Confirmed.

Face wounds decreased, drivers 44%, front seat passengers 63%.

Eye injuries decreased, drivers 38%, front seat passengers 40%.

(10) A reduction in face fractures.

Finding:- No significant overall decrease. Drivers increased by 10%, front seat passengers decreased by 46%. the change in seating distribution is significant.

(11) A reduction in injuries to the lungs.

Finding:- Confirmed. Drivers 33%, front seat passengers 58%.

(12) An increase in sprained necks

Finding:- Confirmed. Drivers 22% front seat passengers 8%, rear seat passengers 26%.

(13) An increase in fractures of the sternum.

Finding:- Confirmed. Drivers from 24 to 48, front seat passengers from 9 to 23.

(14) Back seat passengers should not benefit to the same extent or follow the same pattern as those in the front seat.

Finding:- Confirmed.

(15) Front seat occupants who are belted will have lower mean severity scores in the first year than the second.

Finding:- Not confirmed.

(16) Front seat occupants who are unbelted will have lower mean severity scores in the first year than the second.

Finding:- Confirmed.

(17). Late night and early morning front seat occupants will have lower rates of belt wearing and higher severity scores that at other times of the day.

Finding:- Confirmed.

To summarise, the predictions about deaths, about the average severity of injuries and about a fall in the average severity of injuries for belted front seat occupants were not confirmed; the predictions about major brain injuries, skull fractures and facial fractures were confirmed for front seat passengers only; all the remaining hypotheses were fully confirmed.

There was one hypothesis which we did not originally make, yet which emerged from the statistical testing of our data because of the final form in which the questions were stated. We had predicted a difference in the results for those in the front and back of the car. In the study of many different factors the question put was "Is the change in the factor in question independent of seating position?" The results not only demonstrated great differences between those in the front and back seats, but also between drivers and front seat passengers. In the great majority of these it was shown that there was a favourable change in relation to front seat passengers. In one or two cases the driver appeared to get more advantage than the front seat passenger.

The most striking contrast between the seating positions occurred in the case of major brain injuries, where many fewer front seat passengers sustained injuries in the second year, while more drivers sustained such injuries. Had the extra drivers who sustained severe head injuries been unbelted, they would probably have sustained severe and possibly fatal chest injuries. The apparent increase may only be a change in the location of the injury.

We predicted an increase in the case of two injuries – sprains of the neck and fractures of the sternum. Both were confirmed. The other apparent increase in a major injury which was not predicted was abdominal injuries of organs other than the kidney and bladder. It was especially in the gastrointestinal tract and the mesentery where the adverse effect was most marked. It will be important to do further work to establish or exclude this finding, and if possible to see whether it occurs in people whose belts have been correctly positioned.

10.2 Unpredicted changes

Our work shows many more apparent improvements which had not been predicted, yet where our results suggest improvements or deterioration these now should become hypotheses to be tested out in further work. We list them as follows:-

Apparent changes in the incidences of injuries to drivers which may be associated with increased wearing of seat belts, and deserve further study.

10.2.1 Improvements among drivers

10.2.1.1 Major injuries

Major forearm fracture
Major thigh fracture
Kidney injuries
Major leg fractures

10.2.1.2 Minor injuries

Contusions lower extremity
Abrasions lower extremity
Wounds upper extremity
Contusions upper extremity
Wounds scalp
Wounds lower extremity
Fractured ribs
Minor fractures of forearm
Contusions of back
Tooth injuries
Abrasions upper extremity
Abrasions chest
Contusions abdomen

10.2.2 Disadvantages among drivers

10.2.2.1 Major injuries

Major brain injuries
Injuries to abdominal organs except kidney

10.2.2.2 Minor injuries

Contusions of the neck
Contusions of the scalp
Contusions of the chest
Facial fractures — malar and nose

Apparent changes in the incidence of injuries to front seat passengers which may be associated with increased wearing of seat belts, and deserve further study.

10.2.3 Improvements among front seat passengers

10.2.3.1 Major injuries

Injuries to the kidneys
Major brain injuries
Major thigh injuries

10.2.3.2 Minor injuries

Abrasions on lower extremities
Contusions of lower extremities
Abrasions of upper extremities
Wounds of lower extremities
Wounds of upper extremities
Wounds of scalp
Contusions of upper extremities
Contusions of the scalp
Minor fractured forearm
Contusions of the back
Fractured clavicle

10.2.4 Disadvantages among front seat passengers

10.2.4.1 Major injury

Injury of all abdominal organs except kidney

10.2.4.2 Minor injuries

Contusions of the chest
Contusions of the neck

10.3 Recommendations

We realise that our main responsibility has been to establish the medical effects of compulsory seat belt legislation in the United Kingdom. Our suggestions with regard to the implications of our research are offered with some diffidence; we are speaking more as interested and concerned citizens rather than as technical experts. In this spirit we make the following suggestions:

(1) That steps should be taken at least to maintain the levels of safety which have been obtained beyond the span of the present seat belt legislation (i.e. beyond 31st January 1986).

(2) That the case for the compulsory belting of rear seat passengers should be considered.

(3) That the possibility of improving seat belt design should concentrate on:

(a) Preventing the driver from hitting the steering wheel, in the hope that drivers may receive as much benefit as front seat passengers.

(b) The avoidance of injury to the sternum.

(c) The avoidance of injury to abdominal organs.

(d) The avoidance of flexion and rotation of the lumbar spine.

(4) That the apparent improvements and disadvantages which appeared from our work, but were not predicted and have not been confirmed, should be the subject of further research.

(5) The further research should be carried out on spinal injuries resulting from car crashes, both sprains of the cervical and lumbar spines, and also severe fractures and dislocations.

(6) While traffic law enforcement is important at all times, special attention should be given to the period between 11 p.m. and 3 a.m.

Part Two

Fatality Study

11. A study of fatalities in eight coroners' districts in England

11.1 Introduction

When the main study into the medical effects of seat belts was being planned, the original intention had been to study not only the cases arriving alive at hospital but also those who died prior to reaching the same hospitals. Administrative differences made it virtually impossible in some areas to define which pre-hospital deaths corresponded with which hospital. Because of these and other difficulties, the main study was restricted to the patients who were alive on arrival at hospital.

To compensate to some extent for this omission we approached a number of coroners in Great Britain to ask for their co-operation in a study of car occupant deaths in the periods from 1st April to 30th September in 1982 and 1983, that is, in the year before and the year after the introduction of legislation for the mandatory wearing of seat belts in the front seats of cars. The purpose was to establish the medical effects of the legislation among the casualties who died. The coroners who co-operated in this study were those from Bedfordshire, Birmingham, Cleveland Central, Essex, Nottingham, Sheffield, Staffordshire North and West Somerset.

11.2 Methodology

A researcher (HRMH) visited the offices of the coroners who had agreed to co-operate. From the original reports on fatal casualties from car occupant accidents during the stated period, he completed main data collection forms. These were similar to the main form used in the study of hospital patients with modifications to the boxes for collecting coded information about the injuries to provide space for the greater number of injuries in fatal cases (see Appendix 1).

The three box coding system of the main study was modified by the addition of a fourth box, situated to the left of the original three. This contained a letter or digit which indicated one of the Abbreviated Injury Scale regions or a subregion of it (see Appendix 12). Further space was provided for the cause of death attributed by the coroner and in the case of attribution to multiple injuries the likely main cause of death (judged by WHR) was also entered. Contributing pre-existing medical conditions and post-injury complications were also recorded. Checking of the recorded items and their analysis by computer were carried out as in the study of hospital patients.

11.3 Findings

In the period before legislation there were 101 deaths from injuries to car occupants in the eight coroners' districts under study. In the period after legislation in the same districts there were 75 deaths. This represents a fall of 25.7%. The 101 fatal casualties in the first year were occupants of 87 cars which were involved in 85 accidents. In two accidents there were fatal casualties in two different cars; in the remainder there was only one car with a fatal casualty. In the second year the 75 fatal casualties were in 60 cars which were involved in 57 accidents; in three cases the casualties were in two separate cars. The total number of occupants (fatalities and survivors) in the 87 cars in the first year was 186 and the total number of occupants in the 60 cars in the second year was 139.

A small proportion of minor (AIS 1) external injuries, 49 injuries in all, could not be classified but all moderate and severe injuries (AIS 2–6) were recorded and analysed.

The details of seating position and belting status, the injuries and the causes of death are set out in the accompanying tables. Table 68 shows the distribution of fatal casualties according to seating position, and belted status in each period. The seating position was known for all casualties, but belted status was unknown for 25% in the first year and 13% in the second. Table 69 shows the distributions by seating position and belted status not only of fatal casualties, but of all the occupants of the cars in which fatal accidents occurred. Table 70 shows the ratios of driver to front and rear seat passengers among coroners' casualties compared with ratios among patients and among motorists in the community. The casualty ratios are based on Tables 68 and 69. Table 71 shows the percentage of belted front seat occupants in both years for fatal casualties, and compares this with percentages for all occupants of the cars in which fatalities occurred, with figures for patients in the main study and with those for motorists in the community. In this calculation those whose belted status was unknown have been excluded.

Tables 72, 73 and 74 deal with the severity of the injuries from three distinct yet inter-related aspects, Injury Severity Score, Maximum Abbreviated Injury Scale and Abbreviated Injury Scale. Table 75 presents data on the multiplicity of injuries. Table 76 shows the number of injuries in a number of different body regions and Tables 77–85 break down each region into various anatomical sites, and in some cases different morphologies of lesions. Table 86 presents evidence about the time of death in relation to the accident and admission to hospital. Tables 87 and 88 deal with co-existing medical conditions and complications or disturbances of function which contributed to death. The injuries chiefly contributing to death are shown in Tables 89–90.

11.4 Discussion

The logical foundation in approaching the analysis of the tables is similar to that in the main study. There is evidence that between the two years in question the increase in traffic was of the order of 2–9% (see Section 5.2, relating to the main study). There is no evidence that weather conditions were worse in the first year – if anything the second year was the worse. It would be reasonable, therefore, to expect a slight increase in deaths of car occupants. The comparisons ignore this expectation and therefore would tend to underestimate a benefit due to legislation.

In some tables the numbers of casualties are shown, in others the number of injuries. It might be considered that it is wrong to compare injuries directly, without allowing for the number of people in whom the injuries occurred. However, there is no evidence of any decrease in the numbers of people at risk (rather the reverse). If there are fewer casualties in the second year, it is because fewer injuries were sustained. The injuries are the primary factor and the casualties secondary.

The advantage of comparing injuries directly rather than casualties is that it is possible to compare injuries in each region or organ separately, and merely add numbers when forming groups of injuries. Thus tables show the injuries in the head, thorax, abdomen etc. If one attempted mainly to compare casualties it would be necessary to find how often head injuries occurred on their own, and how often they were combined with injuries in one or several other regions. A complete analysis along these lines would be very complicated, and in this paper we have ignored this aspect, merely comparing the total number of injuries in each region or organ.

11.4.1 Tables 68–71 – Belted status and seating position

The first point to note in Table 68 is the total number of casualties in the two years, 101 in the first and 75 in the second, a decrease of 25.7%. This compares with a figure of 18.0% decrease for Great Britain as a whole, and 40% decrease for Northern Ireland. It will be seen that the number of belted fatalities has increased in year two. This is due to the increased numbers of belted motorists at risk in the second year. As can be seen in Table 4, among driver and front seat passenger motorists in Great Britain in the second year, 95% were belted whereas among the fatal casualties studied in the same period only 73% of front seat occupants were belted.

The seating position is known for all casualties, whereas belting status is unknown for 25% of casualties in the first year and 13% in the second. Subsequent analysis will be based almost entirely on seating position enabling all the data to be used.

In the comparison of percentages of belted front seat occupants, it can be seen that in both years the belting rates among the patients in the main study are lower than the rates among motorists in the community. The rate among occupants of the cars in which there were fatalities is considerably lower, and the rate among fatal casualties is lower still. This is what one would expect if the belt was effective in preventing injury and death. There may also be an association between reckless driving and failure to wear belts.

11.4.2 Severity of Injuries

As would be expected few of the fatal cases had low ISS ratings. A group 1–25 has therefore been used in Table 72. In this group there was a decrease of 31% while for the more severe group the decrease was 24%.

On the maximum abbreviated injury scale, the numbers of fatal cases in MAIS 1, 2 and 3 are small, and have been amalgamated into a single group (Table 73). The decrease in fatal front seat occupant casualties is greatest for the cases of least severity (MAIS 1–3, 41%). The second category, MAIS 4, has a decrease of 38%, and MAIS 5 a decrease of 33%. The most severe category (MAIS 6) shows an increase in the second year of 46%. Seat belts give greatest protection in frontal impacts at moderate speeds. In other accidents at high speed or with severe lateral impacts which cause extreme deformation of the vehicle the presence or absence of a belt can make little or no difference to the outcome and severe or fatal injuries will be caused. The results in Table 6 are consistent with this.

The injuries to front seat occupants in the different AIS grades (Table 74) show similar changes. There is relatively little difference in the percentage decrease for injuries in grades AIS 1 to AIS 4. The decrease of grade 5 injuries appears to be somewhat smaller, and the number of injuries of grade AIS 6 has increased.

11.4.3 Multiplicity of injuries

Table 75 shows the distribution of casualties by the number of serious injuries sustained. Serious means an injury of AIS 3 or over. There has been a decrease of 20% for those with 0–4 serious injuries, and a decrease of 46% in those 5–9 injuries. The numbers of those with over 10 serious injuries are very few, but there is no apparent decrease among this group. Again the very worst cases do not appear to have derived the same benefit as the mild and moderate.

11.4.4 Distribution of injuries in body areas (Tables 76–77)

Before commenting on the details of injuries in various parts of the body, it is worthwhile drawing attention to some differences between this study of deaths and the main study of the injuries of patients arriving alive in hospital. In both studies the accidents by which the injuries were caused could be divided into those where a seat belt might conceivably be expected to make a difference, and those where it is inconceivable that any benefit should result. Among the accidents with live patients there was a fair proportion of accidents which might benefit, whereas among the fatalities there were many more where the speeds were so high, the deformation of the car so gross or the angle of impact so lateral that benefit is unlikely.

The patient study was based on 14,000 cases, and distortions from a few bad accidents are unlikely. However, in the coroners' casualties study there were 176 cases. Especially when these are broken down by year and by seating position, it is obvious that a few accidents of extreme severity may have produced considerable distortions in the figures. It is quite possible that some of the unexpected increases among the injuries of front and rear seat passengers in the second year may have been caused in this way. Nonetheless many trends are seen which seem to run parallel to the changes seen among patients. It seems reasonable to suggest that these changes have been caused by the legislation.

There appear to have been considerable reductions in injuries in the head, the thorax, the abdomen and the external region (skin and subcutaneous tissue). Injuries in the extremities were virtually unchanged, and spinal injuries, although the numbers are small, appear to have increased. As we are concerned with death, the contribution of the external region can largely be ignored, although as will be seen later it includes a small number of extensive burns which caused death. Of the remaining injuries, those in the head and thorax accounted for almost 70%.

The substantial decrease of these injuries in the post legislation year may well be a direct effect of the legislation. It is known that belts sometimes cause injuries to the intestine and mesentery, so a fall of 20% in abdominal injuries appears a satisfactory outcome. The numbers of people with spinal injuries were small. However, we know from our study of patients that cervical sprains increased and probably also lumbar sprains increased in the second year. It is consistent with this that in the most severe accidents, spinal fractures and dislocations, many complicated by cord lesions, should increase. Among patients in hospital it appeared that there might possibly be improvements in several types of limb fractures. A similar improvement does not appear to have occurred in these more severe accidents.

If we compare our findings with those of Gissane (1) in England in 1960–1962 and Hossack (2) in Australia in 1970 (Table 23), we find that there is a very similar percentage distribution of injuries between the various body regions in all three studies. In Table 10 the external region has been omitted, as the vast majority of injuries in this region are of minor severity. (The fatal burns are discussed separately later). Over the years there appear to be two main trends, with head injuries forming a diminishing percentage and extremities an increasing percentage. In 1961 in England the percentage of belt wearers was almost nil. Hossack's study related to the period just prior to the Australian legislation, and a few motorists would have been using belts. By the first year of our study the wearing rate had risen to 40% of front seat occupants and in our second year to 95%.

If instead of comparing the percentage distribution of injuries, we compare the number of injuries per 100 casualties, a different picture emerges.

Gissane's injury rates per fatality are higher than Hossack's, and ours are higher than both previous studies. It is not clear whether this is a real change in the number of injuries taking place, or whether (as seems more likely) our study includes some moderate and minor injuries as well as the most severe injuries documented in the earlier studies.

If we now look not at total car occupants but at front seat occupants (to whom the legislation applied) and rear seat passengers (who were unaffected) in Table 9, we find that the improvements related to the front seat. Some back seat injuries appear to have increased, but the numbers are small, and the differences are probably due to random swings.

It is interesting to see that whereas among patients in hospital the front seat passengers appeared to derive more benefit than drivers, among coroners' casualties the reverse was the case. The greatest improvements for drivers have been in thoracic and abdominal injuries.

11.4.4.1 Distribution of injuries in the head and neck regions (Table 78)

The head injuries have been divided into intracranial, skull fractures, face fractures and others. There was little change in the number of brain injuries among fatally injured drivers, but there was a reduction of about one third in such injuries among front seat passengers; all front seat occupants showed a reduction of about this amount in skull and facial fractures and other injuries. The differences among brain injuries may be due to the same causes as are suggested for hospital cases in Part I of the report (Sections 8.9, 8.16.1 and 9.8.2). The few neck injuries refer to injuries to the larynx and pharynx.

Cervical spine injuries are included in the spinal injuries.

11.4.4.2 Distribution of injuries in thorax (Table 79)

Table 12 gives figures for injuries to lungs and pleura, heart, aorta, fractures of ribs, fractures of the sternum and other injuries. In all these categories there have been decreased injuries in the second year. The decreases in ruptures of the aorta if confirmed as a real effect will be most important, as many of these injuries cause almost instant death.

In relation to rib fractures, it is common that a fracture in, say, the third rib is immediately above one in the fourth rib, and often fractures also in the fifth, sixth and seventh ribs. Occasionally, virtually all the ribs on one side are fractured in a single straight line. In classifying fractured ribs according to the Abbreviated Injury Scale a line of rib fractures is counted as a single injury whether it goes through one rib or many. The numbers of fractures shown for rib fractures in Table 79 refer to such fractures, usually involving a group of ribs. They do not indicate the exact number of ribs which were fractured. Had fractures in individual ribs been counted, the number of fractures would have been several times greater than shown here. It is likely that the relative decreases would have remained the same – 40% less for drivers and 10% less for front seat passengers.

The decrease in fractures of the sternum was unexpected in the light of the increase in this injury among patients after legislation. In the year before legislation it seems likely that many unbelted drivers fractured their sternums against the steering wheel. Wearing of belts appears to have favoured survival of drivers with this type of injury. Drivers' chest injuries decreased by 46.9% compared with front seat passengers' 9.4% decrease.

11.4.4.3 Distribution of injuries in abdomen

The liver is the abdominal organ most often injured in fatal cases, and there has been a decrease of 58% of liver injuries among front seat passengers. Splenic injuries also decreased in both drivers and front seat passengers. The incidence of kidney injuries is low and while among drivers there was a decrease, in front seat passengers the injuries increased. This was probably due to the effect of accidents where belts are ineffective. Injuries to the gastrointestinal tract are very low indeed, and lower in the second year. This is said to be a characteristic seat belt injury (see References (3) to (9), but the early data referred mainly to lap belts rather than the current lap diagonal design. There is no evidence that due to the legislation it has become an important cause of death.

11.4.4.4 Distribution of spinal injuries (Table 81)

These were relatively uncommon, forming 2% of all injuries in the first year and 6% in the second. However, in the first year, injuries involving the cord occurred in one third, and in the second year in one half of the spinal injuries. Of 23 injuries involving the cord, only one was sustained by a back seat passenger. Though the absolute numbers are small. the increase of spinal injuries following legislation raises the suspicion that it is due to the increased wearing of belts, but this hypothesis remains unproved from our data.

The increase in these serious spinal injuries in coroners' casualties runs parallel with an increase in sprains of the spine among patients.

11.4.4.5 Distribution of injuries in extremities (Tables 82 and 83)

The overall picture is of little change between the two years. In both lower and upper extremities the dislocations and fractures of drivers have fallen, while those of front seat passengers have increased. The numbers relating to front seat passengers are very low, and the apparent difference may be spurious.

11.4.4.6 Distribution of external injuries (Table 84)

The overall decrease in the large number of external injuries was 23.7%. As in the report on patient injuries it is probable that wounds have been recorded more accurately than abrasions or contusions. It is interesting that among drivers wounds decreased by 66.2%, and in front seat passengers by 22.2%.

11.4.5 Time of death (Table 85)

Of front seat occupants who were dead before reaching hospital, the decrease in the second year was 18%, whereas of those who died later, the second year decrease was 52%. Clearly the former accidents often have such distortion of the vehicles and massive injuries that seat belts cannot affect the outcome. In the later deaths, the seat belt had a very marked effect.

11.4.6 Cause of death

The pathologists who examined the cases in this study were unaware that these reports would be used for the purpose of a scientific study. There was, therefore, no prior agreement on how to indicate factors contributing to death. However, as in every case a cause of death was stated, it seemed worthwhile to indicate what the declared causes were.

The first group of causes are medical conditions present at the time of accident, and thought to be the sole cause or an important contributory cause to death. These are set out in Table 86. The second group of causes were complications or failures of functions (Table 87). This is the least satisfactory group. In eight cases haemorrhagic shock or hypovolaemia was said to be a cause, and it is clear that this was also present in many cases where the death was due to such injuries as ruptured aorta or wounds of the liver, yet in most of these hypovolaemia was not mentioned. In two cases cardiac arrest was given as a cause of death and it is not clear what is meant. However, we have set down this list under the heading "Complications and Malfunctions" as the incidence of such entities as pulmonary embolus and disseminated candidiasis is likely to be of interest. In 93 cases in the first year and 72 in the second, death was said to be due either to multiple injuries or to one specific injury. In the cases classified "Multiple Injury" one of us (WHR) selected the injury which looked likely to have been the most immediate cause of death. It should be noted that some patients had a medical condition considered as a cause of death, some had a complication or malfunction, and some an injury. Some were given one cause of death and some two or three. Our tables merely show the distribution of each type of cause of death.

11.4.6.1 Medical causes of death (Table 86)

There were eight casualties in the first year and two in the second whose death was attributed largely to a medical condition, although one case of drowning in the second year might be considered a secondary accident rather than a disease. The only condition to contribute more than one death was myocardial infarction (three in the first year and one in the second of fresh infarcts). It is impossible to know whether the lower incidence in the second year was a random swing or whether seat belts by reducing the number of injuries make it less likely that motorists will die of their medical condition.

In the case of acute myocardial infarctions, it is possible that in some cases the infarct occurred as a result of the accident, and it is reasonable to expect that in mitigating chest impacts seat belts might lower the incidence of such infarcts. However, in some cases the infarct may occur prior to the accident and be the true cause of the accident and it would not be reasonable to expect that seat belts would lower the incidence of such infarcts. It could be argued that such cases should be excluded from the survey. In this report we have not excluded them. There are very few such cases and excluding them would not materially affect the overall picture.

11.4.6.2 Complications and malfunctions (Table 87)

This table is obviously incomplete and is mentioned only to indicate the possibility of including this dimension in further studies. It would seem highly desirable to have agreement in advance about the complications and malfunctions which should be included.

11.4.6.3 Main contributory injury to death

Table 88 shows the distribution of the regions in which injuries thought to be causing death were located. The most common regions were chest and head, which were thought to be the main contributors to death in the first year in 83% of the 93 casualties in this group. In the second year the proportion was 69% of 72 casualties.

Table 89 shows the details of injuries within each region. In the head the main contributors to death were brain injuries but there were a few cases where skull and face fractures were considered the chief contributor to death. The injury in the neck which was a main contributor to death was a rupture of the larynx. It should be understood that cervical spine injuries are classified under spine. It will be seen that injuries of the aorta were the largest group in the thorax followed by heart injuries. There were fewer of both under this heading in the second year.

In the abdomen the liver was the main site of injuries causing death. There was a substantial reduction in year two.

Of spinal injuries 13 out of 14 were sited in the cervical spine. This cause of death increased in the second year. The only type of external injury to cause death was burning. The increase in the second year was in a single tragic accident where neither front seat occupant nor rear seat passengers escaped. It cannot be taken as evidence that the legislation increases such injuries.

11.5 Conclusions

National statistics are the best source for demonstrating the reduction in numbers of deaths following the seat belt legislation. The present sample, however, gives more detail of the types of injuries in those who die. It shows that the favourable effect on head, chest and abdominal injuries has probably contributed most to the reduction in mortality.

Comparison of injuries to drivers with those to front seat passengers suggests that in severe impacts current belts permit contact of the driver's head with the steering assembly so giving the driver less protection than the passenger.

Another trend which suggests the need for further study towards improvement of seat belts is the observed rise in numbers of spinal injuries. These comprise only a small proportion of total injuries and our observation is correspondlingly based on few cases and these are far outweighed by advantages in respect of other injuries, but thought should be given to devising ways and means of protecting the neck from injury in car occupant accidents. Our study does not prove that the increased spinal injuries are directly due to the increased wearing of belts, and clearly further work is urgently needed to establish or refute this hypothesis. A study with much larger numbers of fatalities and representative of the whole of the country is now necessary.

11.6 References

(1) GISSANE W. The nature and causation of road injuries. Lancet 1963; 695–698.
(2) HOSSACK D W. The pattern of injuries received by 500 drivers and passengers killed in road accidents. Med J of Aust 1972 (2); 193–195.
(3) GARRETT J W, BRAUNSTEIN P W. The seat belt syndrome. J Trauma 1962; 2: 220–238.
(4) FISH J, WRIGHT R H. The seat belt syndrome — does it exist? J Trauma 1965; 5: 746–50.
(5) HAMILTON J B. Seat belt injuries. Brit Med J 1968; 485–486.
(6) WILLIAMS J S, KIRKPATRICK J R. The nature of seat belt injuries. J Trauma 1971; 2: 207–218.
(7) RYAN P, RAGAZZON R. Abdominal injuries in survivors of road trauma before and since seat belt legislation in Victoria. Aust NZ J Surg 1979.
(8) DAJEE H, MACDONALD A C. Gastric rupture due to seat belt injury. Brit J Surg 1982; 69: 436–437.
(9) DENIS R, ALLARD M, ATLAS H, FARKOUH E. Changing trends with abdominal injuries in seat belt wearers. J Trauma 1983; 23: 1007–8.

12. Acknowledgements

The four researchers are very aware that the success of this project has been due to the willing co-operation of many people.

Firstly we cannot over-emphasise our debt to the people in the Accident and Emergency Departments of the 14 co-operating hospitals. The names of the heads of department are listed in Appendix No 2. The co-operation of these doctors was the foundation of the whole project. However, the actual recording work was done not by these doctors alone, but by a whole succession of junior colleagues. Often at night and often under pressure they noted not only clinical details of patients, but also their seating position and belted status. In many hospitals the doctors were assisted both in the original documentation, and in its transfer to the main data collection forms by receptionists and secretaries. To all such people in all the co-operating hospitals we owe a large debt.

Much of the burden of sorting out all the resultant information fell on people working either in the Medical Computing and Statistics Department of the Queen's University of Belfast, or staff of the Accident and Emergency Department of the Royal Victoria Hospital, Belfast. The coding of the injuries was done by Miss Madeline Hawthorne, the transferring of the encoded data to computer was supervised by Mrs. J J Smith-Davidson. All the final tables were prepared by Miss Joy McCay. For much typing and re-typing in the preparation of this report we would thank especially Mrs. Marie Loughran, Mrs Toni Toal and Miss Angela Franks.

Before the fatality study, Mrs. J K Nelson retired from the Department of Medical Computing and Statistics. The preparation of tables was undertaken by Mr. John McGurk, to whom we are most grateful.

In the collection of information about the context of our study we met universal courtesy and helpfulness. We are especially grateful to the following:–

Transport and Road Research Laboratory, Department of Transport
Department of the Environment, Road Safety Branch, Belfast
Royal Ulster Constabulary, Traffic Branch
Department of Transport's Statistical Department
Meteorological Office
Department of Economic Development, Belfast.

From the start of the project support, help and encouragement have been received from the Casualty Surgeons Association and The Royal Society for the Prevention of Accidents.

Throughout the study the researchers reported their progress to the special committee appointed by the Department of Health and Social Security to oversee the project (Appendix 3). We are greatly in the debt of all the committee members, but particularly to Dr. J F Bull, Dr Peter Scott and Miss

Barbara Sabey who made themselves available to use for advice at any time.

Our special thanks are due to the Coroners of Bedfordshire, Birmingham, Cleveland Central, Essex, Nottingham, Sheffield, Staffordshire North and West Somerset who allowed us to use their records for the fatalities study. We are particularly grateful to all the pathologists whose careful reports supplied the details of all the injuries of these cases.

Finally the study was entirely dependent on financial support, and for this we are grateful to the Department of Health and Social Security for England and Wales, the Department of Health of the Scottish Office and the Department of Health and Social Services of the Northern Ireland Office.

Appendix No. 1

Seat-belt legislation and after

Sir, — At long last we have had a vote in the House of Commons (28 July) in favour of the compulsory wearing of seat belts by drivers and front-seat passengers in cars. Once the euphoria is over we will quickly need to get down to some of the realities. The law will require only the front-seat occupants to be restrained. The majority of rear-seat occupants (who are very nearly as vulnerable as those in the front) will remain unbelted. They will not only run a risk themselves but will also be potential missiles against the now belted front drivers. Efforts must therefore be strengthened to have adequate rear lap-and-diagonal seat belts fitted and used in the rear of all cars.

Children will be required only to be excluded from the front seat or to be adequately restrained if they are in front. The majority of children (around 85% on current estimates) will continue to travel unrestrained in the back. Efforts must therefore be continued to find simple and effective ways of restraining children in the rear of cars. The use of conventional adult belts with booster cushions — recently given some adverse publicity by the *Sunday Times* (26 April) but more balanced treatment by the Automobile Association's magazine *Drive and Trail* (August 1981) — offers a practical answer to the critics who say that existing child bucket seats and harnesses are too difficult to fit and use.

Before the law takes effect in 1982 doctors will be pressed with all manner of excuses to issue exemption certificates on medical grounds. The experience in Scandinavia has been that very few people really have a genuine case for exemption. It may be confidently predicted that the majority of people will comply with the law, especially if a suitably directed publicity campaign is launched prior to the law's taking effect. There will be a small number who will flout the law. If Britain follows the Australian experience, these will be the younger males, the drunken and late-night drivers, and those with criminal records and more deprived social backgrounds, often driving cars of dubious roadworthiness. These are the very ones most at risk anyway and it may prove very difficult to get this small fringe group to comply with the law unless it is strictly enforced.

Since the non-wearing group may also discredit any evaluation of the effectiveness of the legislation (as distinct from the already proved effectiveness of the use of seat belts) it will be vitally important for accident and emergency departments throughout the country to keep accurate records on the use of seat belts by car occupants who become casualties. If we really want to make a worthwhile evaluation then we will also need to measure the severity of injury accurately (for example, by using the American AIS system). We will also need to know more about the long-term outcome in terms of disability and loss of work. None of this should prove to be too difficult and it may be quite enough to do it on a sample basis in a manner similar to the Home Accident Surveillance System. It may be appropriate for the DHSS, the BMA, or one of the royal colleges or faculties to set up a small working party to devise a monitoring system that can be used by accident and emergency departments. This will be necessary in order to have some facts directly applicable to this country when the time comes to evaluate the effectiveness of the law. Such a scheme will need to be set up in the very near future if we are to measure the before-and-after effect. It is very doubtful whether the existing national Statistics 19 Police Notification System, which is the official scheme for recording of road traffic accident casualties, and which classifies accidents into fatal, severe, and slight, is adequate enough to assess the effectiveness of seat-belt legislation.

The seat-belt law promises to be a major milestone in legislation aimed at maintaining the health of the people. The medical profession has an important role to play in supporting all those agencies charged with making the law effective.

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Leamington Spa CV32 4JB

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Appendix No. 2

Hospital	Consultant
Airdrie — Monklands District General Hospital	Dr. Marie Brooks
Belfast — Belfast City Hospital	Dr. Maureen Turtle
Belfast — Royal Victoria Hospital	Mr. W. H. Rutherford
Belfast — Ulster Hospital	Mr. Terry Shaw
Edinburgh — Royal Infirmary	Dr. Keith Lyttle
Hull — Royal Infirmary	Dr. John Gosnold/ Dr. Susan Brooks
Leeds — General Infirmary	Mr. David Wilson
Liverpool — Royal Liverpool Hospital	Mr. Stuart Lord
Nottingham — The Queen's Medical Centre	Dr. Girish Dave/ Dr. Andrew Dove
Salford — Hope Hospital	Mr. David Yates
Southampton — Southampton General Hospital	Dr. Rodger Sleet
Taunton — Taunton and Somerset Hospital	Mr. Chris Cutting
Wakefield — Pinderfields General Hospital	Mr. Andrew Marsden
Wrexham — War Memorial Hospital	Mr. Mike Cook

Appendix No. 3

D.H.S.S. Advisory Committee

Those who met on 21.12.81. were:

Dr. Marguerite Smith	DHSS Chairman
Mr. D. J. Crisp	DHSS
Dr. Mary Dastgir	DHSS
Dr. R. W. Watton	DHSS
Dr. J. P. Bull	Director, MRC Industrial Injuries and Burns Unit, Birmingham.
Miss Mary Christian	Consultant, Accident and Emergency Dept., Wexham Park Hospital, Slough.
Mr. W. H. Rutherford	Consultant, Royal Victoria Hospital, Belfast.

In July 1982 Miss Mary Christian withdrew, and Mr. Rutherford was joined by two other members of the research team, Professor Tony Greenfield, Professor of Medical Computing and Statistics, The Queen's University of Belfast, and Dr. H. R. M. Hayes, Research Fellow. From the start, Miss Sabey of the Transport and Road Research Laboratory was invited to attend, and from September 1982 she was a regular member of the committee. In April 1984 Dr. Mettle replaced Dr. Watton, representing the Department, and as Miss Sabey was going to New Zealand, the Transport and Road Research Laboratory was represented by Mr. Peter Scott. In August 1984, Mrs. R. Balderson of the DHSS joined the committee.

The committee met two or three times a year to receive progress reports.

APPENDIX NO. 4

CAR OCCUPANT INJURY/SEAT BELT STUDY

Patient's Name: ....

1-3 Job Number **1 8 9**
4 Form Number **1**
5 Card Number **1**
6-18 Hospital Number ☐☐☐☐☐☐☐☐☐☐☐☐☐
19-20 Age in years ☐☐
21 Sex (1 = male, 2 = female) ☐

22-27 Date of accident (day : month : year) ☐☐☐☐☐☐
28-31 Time of accident (24 hour clock) ☐☐☐☐
Location of accident

....

32-37 Date of arrival at hospital (day : month : year) ☐☐☐☐☐☐
38-41 Time of arrival at hospital (24 hour clock) ☐☐☐☐
42 Accident - arrival interval ▨
1 = <1hr 2 = 1-3hrs 3 = 3-6hrs 4 = 6-24hrs
5 = 24-48hrs 6 = 48-96hrs 7 => 96hrs

43-47 Accident Number ▨▨▨▨▨
48-49 Vehicle Number ▨▨
50 Patient Number ▨

51 Injury/belt status driver ▨
52 1st FSP ▨
53 2nd FSP ▨
54 1st BSP ▨
55 2nd BSP ▨
56 3rd BSP ▨
57 4th BSP ▨
58 5th BSP ▨
59 6th BSP ▨

0 = None
1 = No injury/no belt
2 = Injury/no belt
3 = No injury/belt
4 = Injury/belt

60 Position of the patient in car ▨
1 = Driver 2 = FSP 3 = BSP

Appendix 4: continued

1-3	Job Number	1 8 9
4	Form Number	1
5	Card Number	2
6-18	Hospital Number	

INJURIES

In each body region make a complete list of all injuries. Abrasions, contusions and wounds are entered as "External" unless exceptionally deep or complicated.

19-28 External

Abrasions and Contusions
Face – state whether < or > 25cm^2
Rest of body – state whether < or > 50cm^2

Wounds
- (a) Through skin only
- (b) Skin and subcutaneous tissue, face state whether < or > 5cms
- (c) Skin and subcutaneous tissue rest of body, state < or > 10cms
- (d) Deeper wounds injuring vessels, nerves, muscles, organs, etc. to be classified in specific body region

Burns
- (a) Superficial burns
- (b) Partial thickness or full thickness. Percentage body surface

Number of injuries

29-38 Head

- (1) State on arrival
  - (a) fully conscious
  - (b) speaking but not fully conscious
  - (c) not speaking, even with painful stimulation.
- (2) Length of unconsciousness – accident till started to speak
- (3) Skull fractures
- (4) Haemorrhages, wounds, etc., found at autopsy, operation or CT scan
- (5) Injuries to nose, eyes, or face – describe

Number of injuries

39-48 Neck

Number of injuries

49-58 Thorax

Number of injuries

59-68 Abdominal Pelvic Contents

Number of injuries

69-78 Spine

Indicate cord lesions as
- (a) Transient with complete recovery
- (b) Incomplete
- (c) Complete
- (d) Level

Number of injuries

Appendix 4: continued

1-3	Job Number	1 8 9
4	Form Number	1
5	Card Number	3
6-18	Hospital Number	

INJURIES (contd.)

Extremities

19-28 Left Arm

Extremities Fractures (All sites – not only extremities)
State Simple compound
comminuted
displaced

Number of injuries

29-38 Right Arm

Number of injuries

39-48 Left Leg

Number of injuries

49-58 Right Leg

Number of injuries

59-60 Injury Severity Score
(Please leave blank)

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61 Condition on arrival at hospital ☐
1 = alive, 2 = dead

62 Was patient admitted to hospital? ☐
1 = Yes, 2 = No

63 Did patient die in hospital? ☐
1 = Yes, 2 = No

64-69 If No, give date of discharge (Code 999999 for outpatient) ☐☐☐☐☐☐
(day : month : year)

70-72 Duration of stay in hospital in days (Code 999 for outpatient) ☐☐☐

73 Was patient wearing a seat belt? ☐
1 = Yes, 2 = No

74 Confidence in answer ☐
1 Very confident
2 Fairly confident
3 Equivocal
4 Fairly unsure
5 Very unsure

75 Blood alcohol level ☐
0 = 0
1 = 1-50 ☐
2 = 51-100
3 = 101-150 ☐
4 = 151-200
5 = 201-250
6 = 251-300 ☐
7 = 301 +

☐

AFFIX FORM No. 1 HERE

APPENDIX NO. 5

FORM No. 1

Reference No. .... Name ....

Time of accident .... Location ....

Car: Colour .... Make .... Type .... No. ....

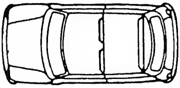
Were you the driver or passenger? Driver/Passenger
Where were you sitting? (Mark X on diagram)
Were you wearing a seat belt?

Yes......... ☐
No.......... ☐

Degree of confidence 1 2 3 4 5
very sure ... very unsure

Patient

A

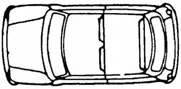


Was anyone else in the car? Yes/No
Where sitting? (Mark X for each person on one diagram)

Other occupants

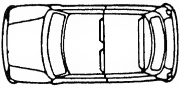
B Wearing a seat belt?	Injured?
Yes .... ☐	Yes .... ☐
No .... ☐	No .... ☐
Not sure or Don't know .... ☐	Don't know .... ☐

B



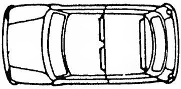
C Wearing a seat belt?	Injured?
Yes .... ☐	Yes .... ☐
No .... ☐	No .... ☐
Not sure or Don't know .... ☐	Don't know .... ☐

C



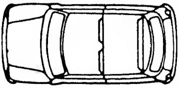
D Wearing a seat belt?	Injured?
Yes .... ☐	Yes .... ☐
No .... ☐	No .... ☐
Not sure or Don't know .... ☐	Don't know .... ☐

D



E Wearing a seat belt?	Injured?
Yes .... ☐	Yes .... ☐
No .... ☐	No .... ☐
Not sure or Don't know .... ☐	Don't know .... ☐

E



Any others? Describe

Appendix No. 6

ALPHABETICAL LIST OF TRAUMA MORPHOLOGY FOR CODING

A. Abrasion
B. Burn
C. Contusion (bruise haematoma)
D. Dislocation
E. Emphysema (surgical)
F. Fracture
G. Foreign body
H. Haemorrhage, haemothorax, hyphema etc.
I. Intracranial injury (concussion, head injury)
L. Ligament injury
M. Muscle injury
N. Nerve injury
P. Perforation
Q. Pneumo (thorax etc.)
R. Rupture
S. Sprain
T. Tendon injury
V. Vessel injury
W. Wound
X. No injuries

Appendix No. 7

SUBDIVISIONS OF AIS REGIONS

External

1. Face
2. Scalp
3. Neck
4. Chest
5. Abdomen
6. Back (spinal, para-spinal)
7. Upper limb
8. Lower limb
9. Genitalia

Head

1. Skull, Brain
2. Face, malar bone cheek
3. Face, maxilla, mouth
4. Face, mandible, chin
5. Eye orbit
6. Nose
7. Ear

Neck

1. Decapitation
2. Oesophagus
3. Pharynx
4. Larynx and trach
5. Thyroid
6. Vessels
7. Nerves
8. Musculo-skeletal

Thorax

1. Lung, pleura, bronchus
2. Heart, pericardium
3. Oesophagus
4. Major arteries
5. Major veins
6. Chest wall — bones
7. Chest wall — soft tissue
8. Diaphragm

Abdominal and Pelvic Contents

1. Stomach
2. Small bowel
3. Large bowel
4. Liver
5. Spleen
6. Kidney, ureter
7. Bladder
8. Genital organs
9. Other

Spine

1. Cervical
2. Thoracic
3. Lumbar
4. Sacral
5. Coccygeal

Without cord or nerve injury

6. Cervical
7. Thoracic
8. Lumbar
9. Sacral

with cord injury

Extremities

1. Thumb, Hallux
2. Index/2nd toe
3. Middle/3rd toe
4. Ring/4th toe
5. Little/5th toe

including MP joint

6. Hand/foot, including wrist/ankle
7. Forearm/leg, including elbow/knee
8. Arm/thigh, including shoulder/hip
9. Collar bone/pelvis

S. Scapula

APPENDIX NO. 8

1982

FOG

		Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Total
London	1	3	1	0	0	0	0	1	4	1	2	2	1	15
Heathrow	2	5	5	1	2	0	0	1	7	8	4	3	2	38
Gatwick	3	8	7	4	9	7	7	9	20	14	4	8	5	102
Manston	4	6	5	4	0	4	3	3	5	3	1	1	2	37
Hurn	5	3	9	7	7	6	4	6	14	11	6	2	2	77
Stansted	7	8	7	5	1	10	7	5	15	10	7	10	4	89
Bedford	9	8	5	1	1	10	3	2	9	8	8	11	3	69
Plymouth	11	1	1	0	7	7	0	1	6	1	3	0	2	29
Leeming	13	6	3	4	0	6	4	5	8	8	4	9	2	59
Valley	14	2	2	4	4	7	6	5	4	0	0	1	3	38
Ringway	15	2	4	5	0	1	3	4	3	3	0	7	1	33
Elmdon	16	5	2	2	1	4	1	3	7	9	6	10	0	50
Watnall	17	8	5	1	3	8	3	3	7	7	6	10	0	61
Lerwick	18	2	0	4	7	8	13	10	4	1	2	1	0	52
Dyce	20	5	1	3	5	7	4	8	2	0	3	1	0	39
Abbotsinch	21	5	2	0	0	1	0	1	3	3	5	1	1	22
Aldergrove	22	5	1	0	3	3	5	4	1	2	5	4	0	33

1983

London	1	4	0	0	0	0	0	1	3	2	4	0	0	14
Heathrow	2	3	2	1	1	0	3	2	1	4	6	5	0	28
Gatwick	3	3	2	8	8	2	7	8	8	6	13	7	0	72
Manston	4	6	1	4	0	2	9	4	3	2	7	1	1	40
Hurn	5	3	7	6	4	1	4	4	6	4	7	5	1	52
Stansted	7	6	4	4	7	4	11	5	5	3	14	5	5	74
Bedford	9	7	1	6	7	2	7	4	5	2	12	8	6	67
Plymouth	11	3	6	0	1	3	2	2	6	6	4	2	0	35
Leeming	13	5	3	4	5	5	10	9	4	2	9	4	10	70
Valley	14	1	2	0	1	2	12	5	5	0	2	1	0	31
Ringway	15	0	3	0	1	0	2	2	2	0	7	2	5	24
Elmdon	16	4	1	2	4	2	7	2	4	2	7	5	5	45
Watnall	17	4	0	5	5	2	7	5	8	0	10	6	12	64
Lerwick	18	3	7	4	5	6	19	16	6	5	2	6	8	87
Dyce	20	6	3	9	14	3	10	6	1	0	8	2	10	72
Abbotsinch	21	7	0	4	0	1	1	5	3	1	4	6	11	43
Aldergrove	22	2	2	1	0	2	1	3	2	0	2	2	6	23

Number of days on which fog reported at 18 weather stations in United Kingdom. (Details supplied by Meteorological Offices, London).

APPENDIX NO. 8

1982

FROST

		Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Total
London	1	2	0	0	0	0	0	0	0	0	0	1	0	3
Heathrow	2	3	3	2	0	0	0	0	0	0	3	6	2	19
Gatwick	3	6	10	6	6	0	0	0	0	2	6	12	3	51
Manston	4	7	4	2	0	0	0	0	0	0	1	5	1	20
Hurn	5	8	8	6	6	0	0	0	0	2	4	8	3	45
Stansted	7	10	6	3	1	0	0	0	0	0	3	10	2	35
Bedford	9	11	7	3	1	0	0	0	0	0	4	12	3	41
Plymouth	11	3	0	0	1	0	0	0	0	0	3	4	1	12
Leeming	13	7	7	4	1	0	0	0	0	2	4	12	2	39
Valley	14	3	1	1	1	0	0	0	0	0	0	3	0	9
Ringway	15	6	1	0	0	0	0	0	0	0	2	9	1	19
Elmdon	16	8	9	3	3	0	0	0	0	2	4	13	1	43
Watnall	17	7	3	0	1	0	0	0	0	1	2	12	3	29
Lerwick	18	1	1	6	2	0	0	0	0	0	3	7	5	25
Dyce	20	7	5	3	4	0	0	0	1	2	5	12	7	46
Abbotsinch	21	5	6	6	3	0	0	0	1	3	8	12	5	49
Aldergrove	22	3	4	1	3	0	0	0	0	0	4	10	4	29

1983

London	1	8	0	0	0	0	0	0	0	0	0	0	1	9
Heathrow	2	16	5	3	0	0	0	0	0	2	4	7	7	44
Gatwick	3	17	10	7	0	0	0	0	0	7	6	11	11	69
Manston	4	14	0	2	0	0	0	0	0	0	2	5	5	28
Hurn	5	17	8	5	0	0	0	0	0	3	5	8	6	52
Stansted	7	17	3	3	0	0	0	0	0	2	6	7	15	53
Bedford	9	19	1	4	0	0	0	0	0	2	6	7	5	44
Plymouth	11	8	0	0	0	0	0	0	0	1	1	2	4	16
Leeming	13	16	5	4	0	0	0	0	0	5	5	4	10	49
Valley	14	10	1	0	0	0	0	0	0	0	2	2	3	18
Ringway	15	14	2	0	0	0	0	0	0	1	5	4	8	34
Elmdon	16	18	3	6	0	0	0	0	0	5	5	7	10	54
Watnall	17	18	1	4	0	0	0	0	0	2	5	5	14	49
Lerwick	18	10	6	4	0	0	0	0	0	0	4	4	16	44
Dyce	20	13	6	9	0	0	0	0	1	2	5	6	17	59
Abbotsinch	21	14	3	15	1	0	0	0	1	3	7	9	14	67
Aldergrove	22	11	3	12	0	0	0	0	0	1	5	4	14	50

Number of days on which ice or frost reported at 18 weather stations in United Kingdom. (Details supplied by Meteorological Offices, London).

APPENDIX NO. 8

1982 SNOW

		Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Total
London	1	2	0	0	0	0	0	0	0	0	0	2	2	6
Heathrow	2	2	2	0	0	0	0	0	0	0	0	2	2	8
Gatwick	3	2	1	0	1	0	0	0	0	0	1	5	2	12
Manston	4	2	2	0	1	0	0	0	0	0	0	1	2	8
Hurn	5	1	0	0	0	0	0	0	0	0	0	0	1	2
Stansted	7	2	1	0	0	0	0	0	0	0	1	4	4	12
Bedford	9	3	3	0	0	0	0	0	0	0	8	5	3	22
Plymouth	11	1	0	0	1	0	0	0	0	0	0	2	2	6
Leeming	13	1	4	1	0	0	0	0	0	0	2	4	6	18
Valley	14	2	2	0	0	0	0	0	0	0	1	2	6	13
Ringway	15	1	3	1	1	0	0	0	0	0	2	7	5	20
Elmdon	16	3	8	0	1	0	0	0	0	0	0	7	4	23
Watnall	17	3	7	1	2	0	0	0	0	0	0	7	5	25
Lerwick	18	3	5	8	4	0	0	0	0	0	7	11	21	59
Dyce	20	1	5	5	3	0	0	0	0	0	3	11	9	37
Abbotsinch	21	3	6	0	4	0	0	0	0	0	5	11	10	39
Aldergrove	22	2	10	1	3	0	0	0	0	0	5	9	10	40

1983

London	1	8	1	2	0	0	0	0	0	0	0	1	8	20
Heathrow	2	10	1	3	0	0	0	0	0	0	0	2	9	25
Gatwick	3	9	1	2	0	0	0	0	0	0	0	2	9	23
Manston	4	7	2	4	0	0	0	0	0	0	0	1	6	20
Hurn	5	7	1	1	0	0	0	0	0	0	0	0	4	13
Stansted	7	13	5	3	0	0	0	0	0	0	0	3	12	36
Bedford	9	8	3	3	0	0	0	0	0	0	0	2	12	28
Plymouth	11	5	0	1	0	0	0	0	0	0	0	0	7	13
Leeming	13	11	5	5	1	0	0	0	0	0	0	2	17	41
Valley	14	3	2	1	0	0	0	0	0	0	0	0	6	12
Ringway	15	12	3	6	0	0	0	0	0	0	0	3	16	40
Elmdon	16	12	5	5	0	0	0	0	0	0	0	2	13	37
Watnall	17	12	4	6	0	0	0	0	0	0	0	2	14	38
Lerwick	18	9	13	7	0	0	0	0	0	2	5	5	20	61
Dyce	20	11	9	12	0	0	0	0	0	0	4	7	22	65
Abbotsinch	21	8	5	5	0	0	0	0	0	0	4	3	21	45
Aldergrove	22	5	7	3	1	0	0	0	0	0	0	1	21	38

Number of days on which snow reported at 18 weather stations in United Kingdom. (Details supplied by Meteorological Offices, London)

Appendix No. 9

Pinderfields Hospital

The data from Pinderfields hospital differ from those of all the other hospitals in that there has been an increase in casualties reported from year one to year two as follows:

		Year one	Year two
Other hospitals	Obs	7294	6040
	Exp	7253	6081
Pinderfields	Obs	306	332
	Exp	347	291

The chi-squared value is 10.9 with one degree of freedom. This is a significant difference in the change ($P < 0.001$).

The attached table shows values for individual months and the expected values for Pinderfields calculated by standardising against the rest of the hospitals.

Using these monthly expected values, X^2 values were calculated. These are significant for most months in year one, but only for May and January in year two.

The total X^2 value is highly significant.

The monthly reported casualties for year one are clearly low except for February, May, October and December. In year two it seems as if high values have been reported for May and January.

Some of these results may be due to random variation but overall the results from Pinderfields should be treated cautiously.

However without any management evidence that incorrect values were recorded, as in the case of the other hospital whose data we excluded, we should include the results in the full data analysis. Although they weaken the overall conclusions, these are nevertheless convincing. Thus it cannot be argued that our conclusions would be less convincing if Pinderfields were excluded.

Therefore it cannot be argued that our conclusions are unacceptable because the data for one hospital out of 14 are unreliable.

APPENDIX NO. 9

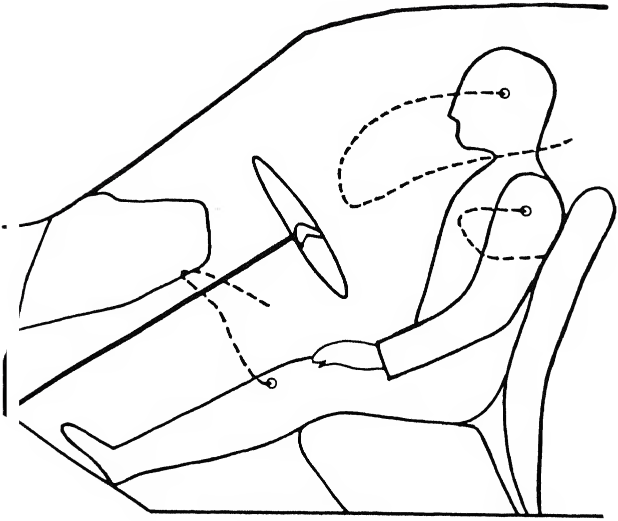
			Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan
Year one	All hospitals except Pinderfields		508	600	564	575	616	492	616	587	599	804	760	573
	Pinderfields	Obs	38	27	18	28	20	15	18	20	42	13	44	23
		Exp	24.3	28.7	27.0	27.5	29.5	23.5	29.5	28.1	28.7	38.5	36.4	27.4
		Diff	+13.7	−1.7	−9.0	0.5	−9.5	−8.5	−11.5	−8.1	+13.3	−25.5	+7.6	−4.4
		X^2	7.72	0.10	3.00	0.01	3.06	3.07	4.48	2.33	6.16	16.89	1.59	0.71
Year two	All hospitals except Pinderfields		402	465	478	547	431	563	421	595	549	614	478	517
	Pinderfields	Obs	25	26	29	39	24	29	22	32	25	26	19	36
		Exp	19.2	22.2	22.9	26.2	20.6	26.9	20.1	28.5	26.3	29.4	22.9	24.7
		Diff	+5.8	+3.8	+6.1	+12.8	+3.4	+2.1	+1.9	+3.5	−1.3	−3.4	−3.9	+11.3
		X^2	1.75	0.65	1.62	6.25	0.56	0.16	0.18	0.43	0.06	0.39	0.66	5.17

Expected values are calculated by using the remaining hospitals as a standard so that

$E = A \times \frac{t}{T}$ where

E = expected value for Pinderfield hospital
t = total casualties over 2 years for Pinderfield hospital
T = total casualties over 2 years for all other hospitals
A = monthly casualties for all hospitals except Pinderfield

Total $X^2 = 67.04$ df = 23 $P < 0.001$



ig. 1: Typical forward displacements in 30 m.p.h velocity change crash with a tight static belt.

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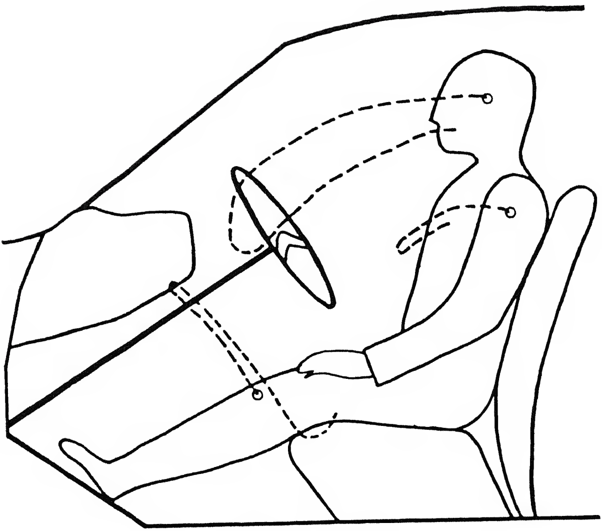

Fig. 2 Typical forward displacements in 30 m.p.h. velocity change crash with a retractor belt.

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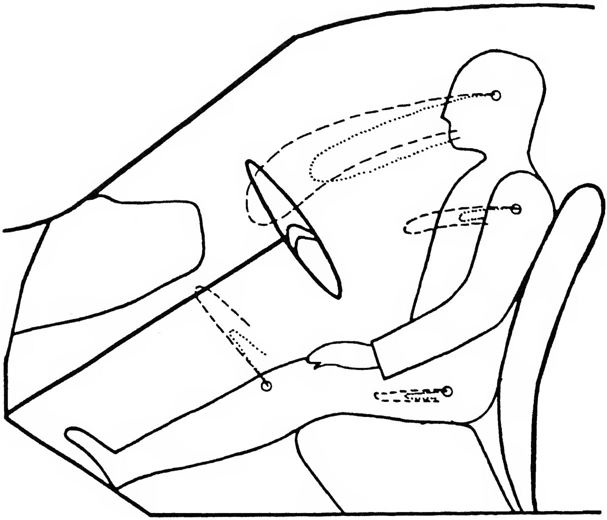

Fig. 3: Typical effect of preloading a retractor belt on forward displacements (head and chest accelerations also decrease).

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APPENDIX 11

1-3	Job Number	1 8 9
4	Form Number	1
5	Card Number	2
6-18	Hospital Number	☐☐☐☐☐☐☐☐☐☐☐☐☐

INJURIES

19					22
23					26
27					30
31					34
35					38
39					42
43					46
47					50
51					54
55					58
59					62
63					66
67					70
71					74
75					78

Belted 1
Unbelted 2 ☐ 79

APPENDIX 11

1-3	Job Number	1 8 9
4	Form Number	1
5	Card Number	3
6-18	Hospital Number	

INJURIES (contd.)

	19					22
	23					26
	27					30
	31					34
	35					38
	39					42
	43					46
	47					50
	51					54
Multiple small injuries	55					58
	59					62
	63					66
Cause of Death	67					70
	71					74
	75					78

79			80

Appendix No. 12

CODING LETTERS OR NUMBERS FOR INDICATION OF REGION OR SUBREGIONS OF ABBREVIATED INJURY SCALE REGIONS

E = External
H = Head
N = Neck
A = Abdomen
T = Thorax
S = Spine
1 = Left upper extremity
2 = Right upper extremity
3 = Left lower extremity
4 = Right lower extremity

Appendix No. 13

GLOSSARY

AIS = Abbreviated injury scale (see Section 3.9)
MAIS = Maximum abbreviated injury scale (see Section 3.9)
ISS = Injury severity score (see Section 3.9)
D = Driver
FSP = Front seat passenger
FSO = Front seat occupant (driver plus front seat passenger)
RSP = Rear seat passenger
T = Total
D1 = Driver in first year
D2 = Driver in second year

Table 1 Hospitals participating in survey into injuries and casualties before and after seat belt legislation

	Hospitals	No. of casualties Year 1	Year 2	% Change	Classification
Airdire	Monklands Hospital	247	220	−10.9	G.B. Urban
Belfast	City Hospital	346	305	−11.8	Northern Ireland
	Royal Victoria Hospital	216	209	−3.2	Northern Ireland
	Ulster Hospital	605	568	−6.1	Northern Ireland
Edinburgh	Royal Infirmary	661	474	−28.3	G.B. Mixed
Hull	Royal Infirmary	852	697	−18.2	G.B. Mixed
Leeds	General Infirmary	761	415	−45.5	G.B. Urban
Liverpool	Royal Hospital	570	436	−23.5	G.B. Urban
Nottingham	University Hospital	1105	1024	−7.3	G.B. Mixed
Salford	Hope Hospital	340	273	−19.7	G.B. Urban
Southampton	General Hospital	984	839	−14.7	G.B. Mixed
Taunton	Taunton & East Somerset Hospital	630	600	−4.8	G.B. Rural
Wakefield	Pinderfields Hospital	320	356	+11.3	G.B. Mixed
Wrexham	War Memorial Hospital	600	561	−6.5	G.B. Rural
		8237	6977		

Table 2 Persons killed or seriously injured in cars and taxis in Great Britain 1980–1983, and traffic volume in 1000 million kilometres

	1980	1981	1982	1983
Traffic in 1000 million kilometers	202.1	203.5	214.8	220.0
Casualties per 1000 million kilometers	164.5	165.2	158.2	156.0† (Predicted had there been no seat belt legislation)
Killed or seriously injured	33,241	33,625	33,985	34,321* (Predicted had there been no seat belt legislation)

* Predicted using first and second differences for 1980/82

† Calculated by dividing predicted casualties by known traffic

Table 3 Total numbers of registered vehicles on the roads 1982 and 1983

	1982	1983	Change
Great Britain	19,724,000	20,216,000	+2.5%
Northern Ireland	423,000	482,000	+4.2%
Total	20,147,000	20,698,000	+2.7%

Figures supplied by the Department of Transport, London and the Department of the Environment, Belfast.

Table 4 Deliveries of Motor Spirit 1982 and 1983 — expressed in thousands of tonnes

	1982	1983	Change
Great Britain	17,942	19,564	+9.0%
Northern Ireland	511	544	+8.4%
Total	18,453	20,108	+9.0%

Figures supplied by the Department of Energy, London and Department of Economic Development, Belfast.

Table 5 Distribution of Accidents and Vehicles by Year

	Year 1	Year 2
Accidents	5557	4837
Vehicles	6010	5165

Table 6 Exclusions – uninjured and dead on arrival

	First Year		Second Year		Total	
No. of patients brought to hospital		8237		6977		15214
Deduct (a) Uninjured	559		559		1118	
(b) Dead on arrival	52		25		77	
	611	611	584	584	1195	1195
Cases subjected to further analysis		7626		6393		14019

Table 7 Distribution by seat belt status, seating position and not known

	Belted status		
Seating position	Known	Not known	Total
Known	(a) 11932	1604	(b) 13536
Not known	129	354	483
Total	12061	1958	(c) 14019

Table 8 Distribution of three major groups by Age

	0–9	10–19	20–29	30–39	40–49	50–59	60–69	70+	NK	MEAN	S.E.
(a)	375	2294	3835	1958	1218	1042	635	467	108	32.5	0.16
%	3.1	19.2	32.1	16.4	10.2	8.7	5.3	3.9	0.9	—	—
(b)	403	2566	4382	2250	1398	1181	707	516	133	32.5	0.15
%	3.0	19.0	32.4	16.6	10.3	8.7	5.2	3.8	1.0	—	—
(c)	412	2665	4551	2340	1439	1211	722	530	149	32.4	0.14
%	2.9	19.0	32.5	16.7	10.3	8.6	5.2	3.8	1.1	—	—

Table 9 Distribution of three major groups by Sex

	M	F	NK
(a)	6805	5123	4
%	57.0	42.9	0.0
(b)	7842	5690	4
%	57.9	42.0	0.0
(c)	8108	5907	4
%	57.8	42.1	0.0

Table 10 Distribution of three major groups by Mortality

	Lived	Died
(a)	11866	66
%	99.4	0.6
(b)	13453	83
%	99.4	0.6
(c)	13933	86
%	99.4	0.6

Table 11 Distribution of 3 major groups by Length of Stay of Inpatients (days)

	0–2	3–14	15–19	60+	NK	Total admitted	MEAN	S.E.
(a)	1327	714	258	90	10	2399	9.2	.425
%	55.3	29.5	10.7	3.7	0.4	100	–	–
(b)	1506	821	307	107	13	2754	9.5	.39
%	54.7	29.8	11.1	3.9	0.5	100	–	–
(c)	1551	840	312	109	14	2826	9.4	.39
%	54.9	29.7	11.0	3.8	0.5	100	–	–

Table 12 ISS

	1–3	4–8	9–15	16–24	25+	MEAN	S.E.
(a)	883	22		13	8	2.8	.04
%	74.0	.	5.	1.	0.7	–	–
(b)	999	25		1	10	2.	.04
%	73.8	1 .	5.	1.2	0.8	–	–
(c)	1037	26	7.7	16	1	2.8	.04
%	74.0	18.9	5.1	1.1	0.8	–	–

Table 13 Distribution of 3 major groups by MAIS* in each Body Region

	EXTERNAL							HEAD						
	0	1	2	3	4	5	6	0	1	2	3	4	5	6
(a)	2831	8456	645					9432	914	1453	74	37	21	1
%	23.7	70.9	5.4					79.0	7.7	12.2	0.6	0.3	0.2	0.0
(b)	3215	9624	697					10715	992	1664	94	45	25	1
%	23.8	71.1	5.1					79.2	7.3	12.3	0.7	0.3	0.2	0.0
(c)	3375	9937	707					11115	1028	1702	98	48	27	1
%	24.1	70.9	5.0					79.3	7.3	12.1	0.7	0.3	0.2	0.0

	NECK							THORAX						
(a)	11911	20			1			11273	347	168	111	26	7	
%	99.8	0.2			0.0			94.5	2.9	1.4	0.9	0.2	0.1	
(b)	13513	21			2			12803	381	188	125	31	8	
%	99.8	0.2			0.0			94.6	2.8	1.4	0.9	0.2	0.1	
(c)	13996	21			2			13259	397	194	129	32	8	
%	99.8	0.1			0.0			94.6	2.8	1.4	0.9	0.2	0.1	

	ABDOMINAL PELVIC CONTENTS							SPINE						
(a)	11806		1	71	26	28		9434	2343	121	29	3	2	
%	98.9		0.0	0.6	0.2	0.2		79.1	19.6	1.0	0.2	0.0	0.0	
(b)	13387		1	81	36	31		10765	2591	141	34	3	2	
%	98.9		0.0	0.6	0.3	0.2		79.5	19.1	1.0	0.3	0.0	0.0	
(c)	13864		1	84	38	32		11128	2707	144	34	3	3	
%	98.9		0.0	0.6	0.3	0.2		79.4	19.3	1.0	0.2	0.0	0.0	

	EXTREMITIES							TOTAL						
(a)	10410	395	793	333	1				8835	2441	523	79	53	1
%	87.2	3.3	6.6	2.8	0.0				74.0	20.5	4.4	0.7	0.4	0.0
(b)	11762	442	934	397	1				9993	2772	610	99	61	1
%	86.9	3.3	6.9	2.9	0.0				73.8	20.5	4.5	0.7	0.5	0.0
(c)	12181	458	973	406	1				10378	2848	624	103	65	1
%	86.9	3.3	6.9	2.9	0.0				74.0	20.3	4.5	0.7	0.5	0.0

*MAIS = Maximum Abbreviated Injury Scale

Table 14 Distribution of 3 major groups by seating position

	D	FSP	RSP	NK
(a)	6590	3246	2096	
%	55.2	27.2	17.6	
(b)	7659	3579	2298	
%	56.6	26.4	17.0	
(c)	7659	3579	2298	483
%	54.6	25.5	16.4	3.4

Table 15 Injuries Classified and Unclassified

	Year 1				Year 2			
	Unclassified	Classified	Total	Unclassified as percentage	Unclassified	Classified	Total	Unclassified as percentage
External	3248	10490	13738	23.6	1480	7297	8777	16.9
Head and Neck	134	2145	2279	5.9	96	1463	1559	6.2
Thorax	56	497	553	10.1	15	457	472	3.2
Abdomen and Pelvic contents	0	96	96	0	22	91	113	19.5
Spine	0	1330	1330	0	13	1598	1611	0.8
Upper Extremities	18	707	725	2.5	4	541	545	0.7
Lower Extremities	107	639	746	14.3	80	621	701	11.4
Total	3563	15904	19467	18.3	1710	12068	13778	12.4

Table 16 Belted and Unbelted

Year 1

	Belted	Unbelted	Total	% Belted	% in each seating position
D	944	2594	3538	26.7	54.5
FSP	416	1464	1880	22.1	29.0
RSP	12	1061	1073	1.1	16.5
			6491		

Year 2

	Belted	Unbelted	Total	% Belted	% in each seating position
D	2816	236	3052	92.3	56.1
FSP	1252	114	1366	91.7	25.1
RSP	34	989	1023	3.3	18.8
			5441		

Table 17 Ratios of driver:front seat passenger:rear seat passenger among motorists in the community, and among patients for the first and second years

	Motorists in Community	Patients First Year	Patients Second Year
Drivers	1	1	1
Front seat passengers	0.50	0.53	0.43
Rear seat passengers	0.35	0.30	0.34

Figures for motorists in the community taken from National Traffic Survey 1978/79

Table 18 Percentage Distribution of Belted Drivers in Great Britain and Northern Ireland (Belfast District) showing patients and motorists in the community

		Great Britain		N.I. (Belfast)	
		Patients	Motorists	Patients	Motorists
Drivers	First Year	26	39	27	26
	Second Year	93	94	90	92
Front Seat Passenger	First Year	23	42	19	24
	Second Year	93	95	88	92

Percentage of belted motorists in the community supplied by the Department of Transport, London and by the Department of the Environment, Belfast.

Table 19 Percentage of belted front seat occupants at different times of the day

	Year 1			Year 2		
	% Belted FSO	% Accidents	Mean ISS	% Belted FSO	% Accidents	Mean ISS
2300 — 0259	17.5	18.6	3.42	84.5	17.0	3.51
0300 — 0759	24.4	6.0	3.46	89.0	5.8	3.52
0800 — 1259	29.2	21.6	2.60	94.7	22.7	2.57
1300 — 1759	27.3	28.3	2.78	94.4	28.8	2.73
1800 — 2259	21.4	25.4	2.73	92.3	25.7	2.63

Table 20 Out-patients, in-patients and hospital deaths

	D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
Not admitted	3199	2868	−10.3	1604	1253	−21.9	4803	4121	−14.2	956	914	−4.4	5759	5035	−12.6
Admitted and discharged	871	669	−23.2	448	255	−43.1	1319	924	−29.9	202	214	+5.9	1521	1138	−25.2
Died in* hospital	24	28	+16.7	10	9		34	37	+ 8.8	9	3		43	40	− 7.0
Total	4094	3565	−12.9	2062	1517	−26.4	6156	5082	−17.4	1167	1131	−3.1	7273	6213	−14.6

* Some of these patients died in the Accident and Emergency Department, but it seems more correct to count all deaths as part of admitted patients.

D_1 = Driver, Year 1 D_2 = Driver, Year 2 FSP = Front Seat Passenger FSO = Front Seat Occupant (i.e. D + FSP)

RSP = Rear Seat Passenger T = Total.

Table 21 Days in hospital

	D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
0–2	493	375	−23.9	265	120	−54.7	758	495	−34.7	122	131	+7.4	880	626	−28.9
3–14	256	224	−12.5	126	101	−19.8	382	325	−14.9	58	56	−3.4	440	381	−13.4
15+	146	97	−33.6	67	43	−35.8	213	140	−34.3	31	30	−3.2	244	170	−30.3
Bed days	8814	6468	−26.6	4272	2794	−34.6	13086	9262	−29.2	1758	1847	+5.1	14844	11109	−25.2

D_1 = Driver, Year 1 D_2 = Driver, Year 2 FSP = Front Seat Passenger FSO = Front Seat Occupant (i.e. D + FSP)
RSP = Rear Seat Passenger T = Total

Table 22 Distribution of Injury Severity Score (ISS)

ISS	D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
1−3	2980	2633	−11.6	1507	1151	−23.6	4487	3784	−15.7		841	−4.5	5368	4625	−13.8
4−8	776	671	−13.5	404	257	−36.4	1180	928	−21.4	219	223	−1.8	1399	1151	−17.7
9−15	243	188	−22.6	108	85	−21.3	351	273	−22.2	53	53		404	326	−19.3
16−24	59	45	−23.7	23	16	−30.4	82	61	−25.6	9	8		91	69	−24.2
25+	36	28	−22.2	20	8	−60.0	56	36	−35.7	5	6		61	42	−31.1

1−3	2980	2633	−11.6	1507	1151	−23.6	4487	3784	−15.7	881	841	−4.5	5366	4625	−13.8
4−8	776	671	−13.5	404	257	−36.4	1180	928	−21.4	219	223	−1.8	1399	1157	−17.7
9+	338	261	−22.8	151	109	−27.8	489	370	−24.3	67	67		556	437	−21.4

D_1 = Driver, Year 1 D_2 = Driver, Year 2 FSP = Front Seat Passenger FSO = Front Seat Occupant (i.e. D + FSP)
RSP = Rear Seat Passenger T = Total

Table 23 Distribution by Maximum Abbreviated Injury Scale (MAIS)

MAIS	D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
1	2980	2633	−11.6	1507	1151	−23.6	4487	3784	−15.7	881	841	−4.5	5368	4625	−13.8
2	851	732	−14.0	443	279	−37.0	1294	1011	−21.9	233	234	+0.4	1527	1245	−18.5
3	208	154	−26.0	84	73	−13.1	292	227	−22.3	45	46	+2.2	337	273	−19.0
4	32	30	−6.3	16	10	−37.5	48	40	−16.7	6	5		54	45	−16.7
5	23	16	−30.4	12	4		35	20	−42.8	2	4		37	24	−35.1
6	0	0		0	0		0	0		0	1		0	1	
3+	263	200	−23.9	112	87	−22.3	375	287	−23.5	53	56	+5.4	428	343	−19.8

D_1 = Driver, Year 1 D_2 = Driver, Year 2 FSP = Front Seat Passenger FSO = Front Seat Occupant RSP = Rear Seat Passenger T = Total

Table 24 Number of injuries by Abbreviated Injury Scale (AIS)

AIS	D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
WHOLE BODY															
1	7089	5419	−23.5	3712	2323	−37.4	10801	7742	−28.3	1891	1740	−7.9	12692	9482	−25.2
2	1471	1208	−17.8	723	470	−34.9	2194	1678	−23.5	341	363	+6.45	2535	2041	−19.4
3	334	265	−20.6	130	106	−18.4	464	371	−20.0	64	70	+9.37	528	441	−16.4
4	46	42	−8.69	23	14	−39.1	69	56	−18.8	9	5		78	61	−21.7
5	25	19	−24.0	15	8	−46.6	40	27	−32.5	2	5		42	32	−23.8
6	0	0		0	0		0	0		0	1		0	1	
3+	405	326	−19.5	168	128	−23.8	573	454	−20.8	75	81	+8.0	648	535	−17.4

D_1 = Driver, Year 1 D_2 = Driver, Year 2 FSP = Front Seat Passenger FSO = Front Seat Occupant RSP = Rear Seat Passenger T = Total

Table 25 Distribution of patients by the number of minor injuries sustained

	D_1	D_2	Change	FSP_1	FSP_2	Change	RSP_1	RSP_2	Change
0	24	25		14	13		11	7	
1	1748	1863	+6.6	794	779	−1.9	530	544	+2.6
2	1015	807	−20.5	532	375	−29.5	318	301	−5.3
3	780	515	−34.0	453	207	−54.3	202	194	−4.0
4	331	227	−31.4	182	95	−47.8	80	63	−21.3
5	113	79	−30.1	49	32	−34.7	17	15	−11.8
6	52	36	−30.8	27	11	−59.3	8	3	−62.5
7	17	9	−47.1	7	3	−57.1	1	2	+100
8	7	4	−42.8	2	2	0	0	2	+ .
9	4	0	−100	2	0	−100	0	0	
10	3	0	−100	0	0		0	0	

Table 26 Distribution of patients by the number of major injuries sustained

0	3831	3365		1950	1430		1114	1075	
1	181	135	−25.4	77	63	−18.2	38	38	0
2	46	34	−26.1	21	15	−27.6	11	12	+9.1
3	18	17	−5.6	10	4	−60.0	2	5	+15.0
4	10	7	−30.0	2	3	+50	1	1	0
5	6	2	−66.7	1	1	0	1	0	−100
6	2	3	+50	1	1	0	0	0	
7	0	0		0	0		0	0	
8	0	2	+	0	0		0	0	

Table 27 Abdominal Contents (Patients)

	D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
GIT	2	7		1	3		3	10		1	0		4	10	
Liver	12	12	0.0	2	3		14	15	+7.1	0	0		14	15	
Spleen	11	7		4	5		15	12	−20.0	2	1		17	13	
Kidney	26	13	−50.0	16	11	−31.2	42	24	−42.8	2	8		44	32	−27.3
Bladder	1	0		1	1		2	1		1	3		3	4	
Peritoneum and other	7	12		2	2		9	14		0	0		9	14	
Genital organs	0	1		0	1		0	2		0	0		0	2	
Kidney	26	13	−50.0	16	11	−31.2	42	24	−42.8	2	8		44	32	−27.3
All other organs	33	39	+18.2	10	15	+50.0	43	54	+25.6	4	4		47	58	+23.4
Total	59	52	−11.9	26	26		85	78	−8.2	6	12		91	90	−1.1

D_1 = Driver, Year 1 D_2 = Driver, Year 2 FSP = Front Seat Passenger FSO = Front Seat Occupant (i.e. D + FSP)
RSP = Rear Seat Passenger T = Total

Table 28 Brain Injury (Patients)

	D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
Minor	606	399	−34.2	296	124	−58.1	902	523	−42.0	151	145	−4.0	1053	668	−36.6
Major	32	46	+43.8	22	13	−40.9	54	59	+9.3	13	13		67	72	+7.5
Total	638	445	−30.4	318	137	−56.9	956	582	−39.1	164	158	−3.7	1120	740	−33.9

D_1 = Driver, Year 1 D_2 = Driver, Year 2 FSP = Front Seat Passenger FSO = Front Seat Occupant (i.e. D + FSP) RSP = Rear Seat Passenger T = Total

Table 29 Eye Injury (Patients)

	D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
Abrasions	15	8		12	7		27	15	−44.4	1	3		28	18	−35.7
Contusions	7	6		1	3		8	9		0	4		8	13	
Foreign body	21	12	−42.8	9	3		30	15	−50.0	4	3		34	18	−47.0
Hyphema	10	4		1	0		11	4		2	2		13	6	
Wounds AIS1	35	29	−17.1	22	18	−18.2	57	47	−17.5	5	4		62	51	−17.7
Wounds AIS2	10	2		8	1		18	3	−83.3	2	0		20	3	−85.0
Total	98	61	−37.8	53	32	−39.6	151	93	−38.4	14	16	+14.3	164	109	−33.5

D_1 = Driver, Year 1 D_2 = Driver, Year 2 FSP = Front Seat Passenger FSO = Front Seat Occupant (i.e. D + FSP) RSP = Rear Seat Passenger T = Total

Table 30 Fractures/Dislocations — Extremities, Lower (injuries)

		D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
TOES	Minor	36	26	−27.8	8	24	+200.0	44	50	+13.6	2	13		46	63	+36.9
FOOT/	Minor	33	39	+18.2	23	17	−26.1	56	56		2	4		58	60	+3.4
ANKLE	Major	4	4		1	1.		5	5		0	0		5	5	
Total		37	43	+16.2	24	18	−25.0	61	61		2	4		63	65	+3.2
LEG/	Minor	86	88	+2.3	32	31	−3.1	118	119	+0.8	13	14	+7.7	131	133	+1.5
KNEE	Major	44	30	−31.8	6	18		50	48	−4.0	7	5		57	53	−7.0
Total		130	118	−9.2	38	49	+28.9	168	167	−0.6	20	19	−5.0	188	186	−1.1
THIGH/	Minor	12	1		1	0		13	1		0	1		13	2	
HIP	Major	81	65	−19.8	32	27	−15.6	113	92	−18.6	22	18	−18.2	135	110	−18.5
Total		93	66	−29.0	33	27	−18.2	126	93	−26.2	22	19	−13.6	148	112	−24.3
PELVIS	Minor	47	37	−21.3	9	19	−111.1	56	56		10	15	+50.0	66	71	+7.6
	Major	5	1		3	0		8	1		0	2		8	3	
Total		52	38	−26.9	12	19	+58.3	64	57	−10.9	10	17	+70.0	74	74	

D_1 = Driver, Year 1 D_2 = Driver, Year 2 FSP = Front Seat Passenger FSO = Front Seat Occupant (i.e. D + FSP) RSP = Rear Seat Passenger T = Total

Table 31 Fractures/Dislocations — Extremities, Lower (patients)

		D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
TOES	Minor	21	21	0.0	7	14		28	35	+25.0	1	7		29	42	+44.8
FOOT/	Minor	31	33	+6.5	17	16	−5.9	48	49	+2.1	2	3		50	52	+4.0
ANKLE	Major	4	4		1	1		5	5		0	0		5	5	
Total		35	37	+5.7	18	17	−5.6	53	54	+1.9	2	3		55	57	+3.6
LEG/	Minor	69	71	+2.9	24	21	−12.5	93	92	−1.1	10	11		103	103	0.0
KNEE	Major	28	19	−32.1	4	13		32	32		3	3		35	35	
Total		97	90	−7.2	28	34	+21.4	125	124		13	14	+7.7	138	138	
FEMUR/	Minor	8	1		1	0		9	1		0	1		9	2	
HIP	Major	74	61	−17.6	30	24	−20.0	104	85	−18.3	20	17	−15.0	124	102	−17.7
Total		82	62	−24.4	31	24	−22.6	113	86	−23.9	20	18	−10.0	133	104	−21.8
PELVIS	Minor	32	28	−12.5	7	13		39	41	+5.1	7	10		46	51	+10.9
	Major	4	1		2	0		6	1		0	1		6	2	
Total		36	29	−19.4	9	13		45	42	−6.7	7	11		52	53	+1.9

D_1 = Driver, Year 1 D_2 = Driver, Year 2 FSP = Front Seat Passenger FSO = Front Seat Occupant (i.e. D + FSP) RSP = Rear Seat Passenger T = Total

Table 32 Fractures/Dislocations — Extremities, Upper (injuries)

		D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
FINGERS	Minor	74	70	−5.4	24	25	+4.2	98	95	−3.1	23	15	−34.8	121	110	−9.1
	Major	0	0		0	0		0	0		0	0		0	0	
Total		74	70	−5.4	24	25	+4.2	98	95	−3.1	23	15	−34.8	121	110	−9.1
HANDS	Minor	24	11	−54.2	12	8	−33.3	36	19	−47.2	5	4		41	23	−43.9
	Major	1	0		2	0		3	0		0	1		3	1	
Total		25	11	−56.0	14	8	−42.9	39	19	−51.3	5	5		44	24	−45.4
FOREARM	Minor	88	52	−40.9	43	18	−58.1	131	70	−46.6	23	20	−13.0	154	90	−41.6
	Major	33	15	−54.5	13	15	+15.4	46	30	−34.8	9	16	+77.8	55	46	−16.4
Total		121	67	−44.6	56	33	−41.1	177	100	−43.5	32	36	+12.5	209	136	−34.9
ARMS	Minor	23	15	−34.8	17	11	−35.3	40	26	−35.0	8	10	+25.0	48	36	−25.0
	Major	10	11		6	2		16	13	−18.7	4	3		20	16	−20.0
Total		33	26	−21.2	23	13	−43.5	56	39	−30.3	12	13	+8.3	68	52	−23.5
COLLAR BONE	Minor	48	43	−10.4	32	18	−43.7	80	61	−23.7	19	15	−21.1	99	76	−23.2
SCAPULA	Minor	17	10	−41.2	6	3		23	13	−43.5	4	2		27	15	−44.4

D_1 = Driver, Year 1 D_2 = Driver, Year 2 FSP = Front Seat Passenger FSO = Front Seat Occupant (i.e. D + FSP) RSP = Rear Seat Passenger T = Total

Table 33 Fractures/Dislocations — Extremities, Upper (Patients)

		D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
FINGERS	Minor	55	56	+1.8	21	21	0.0	76	77	+1.3	22	11	−50.0	98	88	−10.2
	Major	0	0		0	0		0	0		0	0		0	0	
Total		55	56	+1.8	21	21	0.0	76	77	+1.3	22	11	−50.0	98	88	−10.2
HAND/	Minor	23	11	−52.2	12	8		35	19	−45.7	5	4		40	23	−42.5
WRIST	Major	1	0		2	0		3	0		0	1		3	1	
Total		24	11	−54.2	14	8	−42.9	38	19	−50.0	5	5		43	24	−44.2
FOREARM/	Minor	75	43	−42.7	37	16	−56.8	112	59	−47.3	20	16	−20.0	132	75	−43.2
ELBOW	Major	26	11	−57.7	12	11		38	22	−42.1	9	8		47	30	−36.2
Total		101	54	−46.5	49	27	−44.9	150	81	−46.0	29	24	−17.2	179	105	−41.3
ARM	Minor	22	15	−31.8	16	11	−31.3	38	26	−31.6	8	9		46	35	−23.9
	Major	10	11		6	2		16	13	−18.7	4	3		20	16	−20.0
Total		32	26	−18.8	22	13	−40.9	54	39	−27.8	12	12	0.0	66	51	−22.7
CLAVICLE		48	43	−10.4	32	18	−43.7	80	61	−23.7	18	15	−16.7	98	76	−22.4
SCAPULA		17	10	−41.2	5	3		22	13	−40.9	4	2		26	15	−42.3

D_1 = Driver, Year 1 D_2 = Driver, Year 2 FSP = Front Seat Passenger FSO = Front Seat Occupant (i.e. D + FSP) RSP = Rear Seat Passenger T = Total

Table 34 Fractures, extremities, lower, both years together, left and right

	Left Drivers Y1+Y2	Right Drivers Y1+Y2	Percentage on right	Left FSP Y1+Y2	Right FSP Y1+Y2	Percentage on left
Toes	9	20	69%	11	6	65%
Foot	20	36	64%	19	14	58%
Leg	61	63	50.8%	35	23	60%
Thigh	31	77	71%	29	19	60%
Pelvis	17	39	70%	10	11	48%
Total	138	235	63%	104	73	59%

Table 35 Fractures, extremities, upper, both years together, left and right

	Left Drivers Y1+Y2	Right Drivers Y1+Y2	Percentage on right	Left FSP Y1+Y2	Right FSP Y1+Y2	Percentage on left
Fingers	36	52	59.1%	18	15	54.5%
Hand	9	16	64%	12	8	60%
Forearm	52	76	59.4%	25	37	40.3%
Arm	17	24	58.5%	15	12	55.6%
Clavicle	22	34	60.7%	31	13	70.5%
Scapula	8	7		4	4	
Total	144	209	59.2%	105	89	54.1%

Table 36 Fractures, extremities, lower, both years separately, left and right

	Left D1	Right D1	% on R	Left D2	Right D2	% on R	Left FSP1	Right FSP1	% on L	Left FSP2	Right FSP2	% on L
Toes	6	7		3	13		4	0		7	6	
Foot	8	19		12	17		12	6		7	8	
Leg	36	20		25	43		14	12		21	11	
Thigh	15	45		16	32		17	10		12	9	
Pelvis	11	21		6	18		4	4		6	7	
Total	76	112	60%	62	123	67%	51	32	63%	53	41	56%

Table 37 Fractures, extremities, upper, both years separately, left and right

	Left D1	Right D1	% on R	Left D2	Right D2	% on R	Left FSP1	Right FSP1	% on L	Left FSP2	Right FSP2	% on L
Fingers	23	23		13	29		10	7		8	8	
Hand	8	11		1	5		9	3		3	5	
Forearm	36	47	57%	16	29	64%	17	20	46%	8	17	32%
Arm	13	12		4	12		9	8		6	4	
Clavicle	16	24		6	28		19	8		12	5	
Scapula	5	8		3	4		2	3		2	1	
Total	101	125	55%	43	107	71%	66	49	57%	39	42	48%

Table 38 Fractures of clavicle, left and right, belted and unbelted

	Driver				Front Seat Passenger			
	Year 1	Year 2	Unbelted	Belted	Year 1	Year 2	Unbelted	Belted
Left clavicle	16	6	13	9	19	12	17	14
Right clavicle	24	28	20	32	8	5	6	7

Table 39 Fractures/Dislocations — Face (patients)

		D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
MALAR	Minor	11	16	+44.5	5	0		16	16	0.0	4	9		20	25	+25.0
	Major	0	3		2	1		2	4		0	0		2	4	
	Total	11	19	+72.7	7	1		18	20	+11.1	4	9		22	29	+31.8
MIDDLE THIRD	Minor	15	11	−26.7	2	2		17	13	−23.5	4	2		21	15	−28.6
	Major	3	3		2	2		5	5		0	3		5	8	
	Total	18	14	−22.2	4	4		22	18	−18.2	4	5		26	23	−11.5
MANDIBLE	Minor	24	22	−8.3	11	7		35	29	−17.1	4	6		41	33	−19.5
	Major	1	0		2	0		3	0		0	0		3	0	
	Total	25	22	−12.0	13	7		38	29		4	6		44	33	−25.0
ORBIT	Minor	2	3		3	0		5	3		0	1		5	4	
NOSE	Minor	78	88	+12.8	31	20	−35.5	109	108	−0.9	22	14	−36.4	131	122	−6.9
	Major	0	1		1	0		1	1		0	0		1	1	
	Total	78	89	+14.1	32	20		110	109	−0.9	22	14	−36.4	132	123	−6.9
FACIAL TOTAL	Minor	130	140	+7.7	52	29	−44.2	182	169	−7.1	36	30	−16.7	218	199	−8.7
	Major	4	7		7	3		11	10		0	3		11	13	
GRAND	TOTAL	134	147	+9.7	59	32	−45.8	193	179	−7.3	36	33	−8.3	229	212	−7.4

D_1 = Driver, Year 1 D_2 = Driver, Year 2 FSP = Front Seat Passenger FSO = Front Seat Occupant (i.e. D + FSP)
RSP = Rear Seat Passenger T = Total

Table 40 Fractures — Ribs and Sternum (patients)

		D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
RIBS	Minor	140	86	−38.6	48	49	+2.1	188	135	−28.2	14	18	+28.6	202	153	−24.3
	Major	11	9		3	3		14	12		0	1		14	13	
	Total	151	95	−37.1	51	52	+2.0	202	147	−27.2	14	19	+35.7	216	166	−23.1
STERNUM	Minor	21	42	+100.0	8	21	+162.5	29	63	+117.2	3	4		32	67	+109.4
	Major	3	6		1	2		4	8		0	0		4	8	
	Total	24	48	+100.0	9	23	+155.6	33	71	+115.2	3	4		36	75	+108.3

D_1 = Driver, Year 1 D_2 = Driver, Year 2 FSP = Front Seat Passenger FSO = Front Seat Occupant (i.e. D + FSP)
RSP = Rear Seat Passenger T = Total

Table 41 Fractures — Skull (patients)

	D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
Minor	27	29	+7.4	14	4		41	33	−19.5	11	11		52	44	−15.4
Major	11	10		3	1		14	11	−21.4	3	2		17	13	−23.5
Total	38	39	+2.6	17	5	−70.6	55	44	−20.0	14	13	−7.1	69	57	−17.4

D_1 = Driver, Year 1 D_2 = Driver, Year 2 FSP = Front Seat Passenger FSO = Front Seat Occupant (i.e. D + FSP)
RSP = Rear Seat Passenger T = Total

Table 42 Fractures/Dislocations — spine (patients)

		D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
CERVICAL	Minor	9	15		11	9		20	24		2	4		22	28	
No cord damage	Major	12	2		2	1		14	3		1	1		15	4	
Cord damage	Major	1	2		0	0		1	2		0	2		1	4	
	Total	22	19	−13.6	13	10		35	29	−17.1	3	7		38	36	−5.3
THORACIC	Minor	7	10		9	9		16	19		2	2		18	21	
No cord damage	Major	1	0		0	1		1	1		0	0		1	1	
Cord damage	Major	0	0		2	0		2	0		0	0		2	0	
	Total	8	10		11	10		19	20		2	2		21	22	
LUMBAR	Minor	13	9		5	9		18	18		4	4		22	22	
TOTAL No cord damage		42	36	−14.3	27	29	+7.4	69	65	−5.8	9	11		78	76	−2.6
TOTAL Cord damage		1	2		2	0		3	2		0	2		3	4	
GRAND	TOTAL	43	38	−11.6	29	29	0.0	72	67	−6.9	9	13		81	80	−1.2

D_1 = Driver, Year 1 D_2 = Driver, Year 2 FSP = Front Seat Passenger FSO = Front Seat Occupant (i.e. D + FSP)
RSP = Rear Seat Passenger T = Total

Table 43 Sprains (patients)

	D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
SPINE															
Cervical	736	901	+22.4	320	346	+8.1	1056	1247	+18.1	81	102	+25.9	1151	1349	+18.6
Thoracic	3	4		1	4		4	8		0	0		4	8	
Lumbar	22	64	+190.9	8	33	+312.5	30	97	+223.3	9	11		39	108	+176.9
UPPER LIMB															
Fingers	10	4		4	5		14	9		3	1		17	10	−41.2
Wrist	14	10		5	4		19	14	−26.3	0	2		19	16	−15.8
Elbow	5	3		4	1		9	4		0	2		9	6	
Shoulder	20	22	+10.0	7	8		27	30	+11.1	1	2		28	32	+14.3
Acromio clavicular	2	1		0	1		2	2		0	0		2	2	
Total	51	40	−21.6	20	19	−5.0	71	59	−16.9	4	7		75	66	−12.0
LOWER LIMB															
Ankle	25	26	+4.0	14	19	+35.7	39	45	+15.4	6	9		45	54	+20.0
Knee	19	22	+10.5	10	6		29	28	−3.4	5	0		34	28	−17.6
Hip	2	4		0	1		2	5		0	0		2	5	
Total	46	53	+13.0	24	26	+8.3	70	78	+11.4	11	9		81	87	+7.4

D_1 = Driver, Year 1 D_2 = Driver, Year 2 FSP = Front Seat Passenger FSO = Front Seat Occupant (i.e. D + FSP)
RSP = Rear Seat Passenger T = Total

Table 44 Superficial Injuries Abrasions (injuries)

	D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
Face	345	172	−50.1	177	70	−60.5	522	242	−53.6	110	109	−0.91	632	351	−44.5
Scalp	42	44	+4.8	16	7		58	51	−12.1	13	20		71	71	0.0
Neck	20	7		5	12		25	19		3	2		28	21	
Chest	41	25	−39.0	11	25	+127.3	52	50	−3.8	7	8		57	58	−1.7
Abdomen	7	7		4	0		11	7		1	3		12	10	
Back	26	22		18	16		44	38		16	9		60	47	
Upper Extremities	258	246	−4.7	171	90	−47.4	429	336	−21.7	86	87	+1.2	515	423	−17.9
Lower Extremities	425	336	−20.9	275	131	−52.4	700	467	−33.3	175	164	−6.3	875	631	−27.9
Genitalia	0	0		0	0		0	0		0	0		0	0	
Total	1164	859	−26.2	677	351	−48.2	1841	1210	−34.3	411	402	−2.2	2252	1612	−28.4

D_1 = Driver, Year 1 D_2 = Driver, Year 2 FSP = Front Seat Passenger FSO = Front Seat Occupant (i.e. D + FSP) RSP = Rear Seat Passenger T = Total

Table 45 Superficial Injuries Abrasions (Patients)

	D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
Face	317	163	−48.6	165	65	−60.6	482	228	−52.7	105	99	−5.7	587	327	−44.3
Scalp	41	43	+4.9	16	6	−62.5	57	49	−14.0	13	19	+37.5	70	68	−2.9
Neck	20	7		4	12		24	19		3	2		27	21	−22.2
Chest	40	25	−37.5	11	25	+127.3	51	50	−2.0	7	8		58	58	−0.0
Abdomen	7	7		4	0		11	7		1	3		12	10	
Back	25	22	−12.0	17	15	−11.8	42	37	−11.9	14	9		56	46	−17.9
Upper Extremities	227	208	−8.4	146	74	−49.3	373	282	−24.4	77	79	+2.6	450	361	−19.8
Lower Extremities	364	270	−25.8	226	107	−52.7	590	377	−36.1	142	124	−12.7	732	501	−31.6
Genitalia	0	0		0	0		0	0		0	0		0	0	

D_1 = Driver, Year 1 D_2 = Driver, Year 2 FSP = Front Seat Passenger FSO = Front Seat Occupant (i.e. D + FSP) RSP = Rear Seat Passenger T = Total

Table 46 Superficial Injuries Contusions (Injuries)

	D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
Face	696	308	−55.7	412	124	−69.9	1108	432	−61.0	257	167	−35.0	1365	599	−56.1
Scalp	142	181	+27.5	82	60	−26.8	224	241	+7.6	59	98	+66.1	283	339	+19.8
Neck	53	118	+122.6	37	53	+43.2	90	171	+90.0	9	25	+177.8	99	196	+98.0
Chest — superficial	440	430	−2.3	176	255	+44.9	616	685	+11.2	81	63	−22.2	697	748	+7.3
Chest — deep	52	83	+59.6	24	33	+37.5	76	116	+52.6	6	15		82	131	+59.8
Chest — total	492	513	+43.0	200	288	+44.0	692	801	+15.8	87	78	−10.3	779	879	+12.8
Abdomen	50	40	−20.0	19	28	+47.3	69	68	−1.4	9	10	+11.1	78	78	0.0
Back	109	89	−18.3	63	48	−23.8	172	137	−20.3	41	22	−46.3	213	159	−25.4
Upper Extremities	372	285	−23.4	200	159	−20.5	572	444	−22.4	122	119	−2.5	694	563	−18.9
Lower Extremities	520	409	−21.3	335	205	−38.8	855	614	−28.2	243	180	−25.9	1098	794	−27,7
Genitalia	2	0		0	0		2	0		0	0		2	0	

D_1 = Driver, Year 1 D_2 = Driver, Year 2 FSP = Front Seat Passenger FSO = Front Seat Occupant (i.e. D + FSP) RSP = Rear Seat Passenger T = Total

Table 47 Superficial Injuries Contusions (Patients)

	D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
Face	662	292	−55.9	387	121	−68.7	1049	413	−60.6	237	155	−35.6	1286	568	−55.8
Scalp	142	180	+26.8	81	60	−25.9	223	240	+7.6	59	97	+64.4	282	337	+19.5
Neck	53	117	+120.8	36	53	+47.2	89	170	+91.0	9	25	+177.8	98	195	+99.0
Chest — superficial	433	424	−2.1	172	252	+46.5	605	676	+11.7	81	62	−23.5	66	738	−7.6
Chest — deep	51	80	+56.9	22	32	+45.5	73	112	+53.4	6	15	+150.0	79	127	+60.8
Chest — total	484	504	+4.3	194	284	+46.4	678	788	+16.2	87	77	−11.5	765	865	+13.1
Abdomen	50	40	−20.0	19	27	+42.1	69	67	−2.9	9	10	+11.1	78	77	−1.3
Back	104	83	−20.2	62	45	−27.4	166	128	−22.9	40	21	−47.5	206	151	−26.7
Upper Extremities	349	268	−23.2	183	147	−19.7	532	415	−22.0	112	112	0.0	664	527	−20.6
Lower Extremities	459	353	−23.1	283	177	−37.5	742	530	−28.6	202	154	−23.8	994	684	−27.5
Genitalia	2	0		0	0		2	0		0	0		2	0	

D_1 = Driver, Year 1 D_2 = Driver, Year 2 FSP = Front Seat Passenger FSO = Front Seat Occupant (i.e. D + FSP) RSP = Rear Seat Passenger T = Total

Table 48 Superficial Injuries Wounds (Injuries)

	D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
FACE															
Forehead															
Cheeks	1128	599	−46.9	660	214	−67.6	1788	813	−54.5	229	201	−12.2	2017	1014	−49.7
Chin															
Mouth	176	96	−45.4	49	23	−53.1	225	119	−47.1	41	40	−2.4	266	159	−40.1
Eyes	50	37	−26.0	34	19	−44.1	84	56	−33.3	7	4		91	60	−34.1
Total	1354	732	−45.9	743	256	−65.6	2097	988	−52.9	277	245	−11.6	2374	1233	−48.1
SCALP	287	212	−26.1	114	69	−39.5	401	281	−29.9	60	79	−31.7	461	360	−21.9
NECK	14	9		10	7		24	16		6	2		30	18	
CHEST	14	3		6	3		20	6		2	3		22	9	
ABDOMEN	4	0		0	0		4	0		0	0		4	0	
BACK	12	4		7	1		19	5		2	3		21	8	
UPPER LIMB	357	251	−29.7	148	91	−38.5	505	342	−32.3	53	50	−5.7	558	392	−29.7
LOWER LIMB	292	216	−26.0	188	92	−51.1	480	308	−35.8	82	68	−17.1	562	376	−33.1
GENITALIA	0	0		0	0		0	0		0	0		0	0	
TOTAL	2108	1294	−38.6	1133	477	−57.9	3241	1771	−45.4	434	406	−6.5	3675	2177	−40.8

D_1 = Driver, Year 1 D_2 = Driver, Year 2 FSP = Front Seat Passenger FSO = Front Seat Occupant (i.e. D + FSP) RSP = Rear Seat Passenger T = Total

Table 49 Superficial Injuries Wounds (Injuries)

	D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
FACE															
Forehead															
Cheeks	903	500	−44.6	478	168	−64.8	1381	668	−51.6	189	169	−10.6	1570	837	−46.7
Chin															
Mouth	156	86	−44.9	47	20	−57.4	203	106	−47.8	37	35	−5.4	240	141	−41.2
Eyes	42	31	−26.2	28	18	−35.7	70	49	−30.0	7	4		77	53	−31.2
Total	1101	617	−44.0	553	206	−62.7	1654	823	−50.2	233	208	−10.7	1887	1031	−45.4
SCALP	268	192	−28.3	109	68	−37.6	377	260	−31.0	59	75	+27.1	436	335	−23.2
NECK	11	9		10	7		21	16		6	2		27	18	
CHEST	13	3		6	3		19	6		2	3		21	9	
ABDOMEN	4	0		0	0		4	0		0	0		4	0	
BACK	9	4		6	1		15	5		2	3		17	8	
UPPER LIMB	300	209	−30.3	125	78	−37.6	425	287	−32.5	45	47	+4.4	470	334	−28.9
LOWER LIMB	248	178	−28.2	149	78	−47.7	397	256	−35.5	65	51	−21.5	462	307	−33.5
GENITALIA	0	0		0	0		0	0		0	0		0	0	

D_1 = Driver, Year 1 D_2 = Driver, Year 2 FSP = Front Seat Passenger FSO = Front Seat Occupant (i.e. D + FSP) RSP = Rear Seat Passenger T = Total

Table 50 Thoracic contents (patients)

	D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
Lungs and pleura	63	42	−33.3	24	10	−58.3	87	52	−40.2	7	1		94	53	−43.6
Heart and vessels	5	4		2	0		7	4		0	0		7	4	
Total	68	46	−32.4	26	10	−61.5	94	56	−40.4	7	1		101	57	−43.6

D_1 = Driver, Year 1 D_2 = Driver, Year 2 FSP = Front Seat Passenger FSO = Front Seat Occupant (i.e. D + FSP) RSP = Rear Seat Passenger T = Total

Table 51 Miscellaneous Injuries Burns (Injuries)

	D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
Face	0	1		0	0		0	1		0	0		0	1	
Scalp	0	0		0	0		0	0		0	0		0	0	
Neck	0	2		2	1		2	3		0	0		2	3	
Chest	0	1		0	0		0	1		0	0		0	1	
Abdomen	0	0		0	0		0	0		0	0		0	0	
Back	0	0		0	1		0	1		0	0		0	1	
Upper Extremities	0	2		0	3		0	5		1	0		1	5	
Lower Extremities	0	0		3	0		3	0		0	0		3	0	
Genitalia	0	0		1	2		1	2		0	0		1	2	

D_1 = Driver, Year 1 D_2 = Driver, Year 2 FSP = Front Seat Passenger FSO = Front Seat Occupant (i.e. D + FSP) RSP = Rear Seat Passenger T = Total

Table 52 Miscellaneous Injuries Tooth injuries (patients)

	D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
Dislocated teeth	16	5		8	3		24	8	−66.7	1	6		25	14	−44.0
Fractured teeth	32	22	−31.3	19	8	−57.9	51	30	−41.2	5	7		56	37	−33.9
Total	48	27	−43.8	27	11	−59.3	75	38	−49.3	6	13		81	51	−37.0

D_1 = Driver, Year 1 D_2 = Driver, Year 2 FSP = Front Seat Passenger FSO = Front Seat Occupant (i.e. D + FSP)
RSP = Rear Seat Passenger T = Total

Table 53 Head and Neck, Anatomical Region (not by AIS)

(a) Injuries where there was a reduction of patients in both drivers and front seat passengers
(b) Injuries where there was an increase in patients in drivers, front seat passengers or both

		D_1	D_2	% change	FSP_1	FSP_2	% change
(a)	Abrasions — face	317	163	−48.6	165	65	−60.6
	Brain injuries — Minor	606	399	−34.2	296	124	−58.1
	Contusions — face	662	292	−55.9	387	121	−68.7
	Eye injuries	98	61	−37.8	53	32	−39.6
	Middle third — fractures	18	14	−22.2	4	4	
	Mandibular — fractures	25	22	−12.0	13	7	
	Tooth injuries	48	27	−43.8	27	11	−59.3
	Wounds — Forehead, Cheeks, Chin	903	500	−44.6	478	168	−64.8
	Wounds — Mouth	156	86	−44.9	47	20	−57.4
	Wounds — Scalp	268	192	−28.3	109	68	−37.6
(b)	Brain injury — Major	32	46	+43.8	22	13	−40.9
	Contusion — scalp	142	180	+26.8	81	60	−20.9
	Abrasion — scalp	41	43	+4.9	16	6	
	Contusion — neck	52	117	+120.8	36	53	+42.7
	Fractured Malar	11	19	+72.7	7	1	
	Fractured Nose	78	89	+14.1	32	20	−37.5
	Fractured Skull	38	39	+2.6	17	5	−70.6

Table 54 Chest, Anatomical Region (not by AIS)

(a) Injuries where there was a reduction of patients in both drivers and front seat passengers
(b) Injuries where there was an increase in patients in drivers, front seat passengers or both

		D_1	D_2	% change	FSP_1	FSP_2	% change
(a)	Lungs/Pleura	63	42	−33.3	24	10	−58.3
(b)	Contusions — chest wall	484	505	+4.3	194	284	+46.4
	Fractures — ribs	151	95	−37.1	54	52	+2.0
	Fractures — sternum	24	48	+100.0	9	23	+155.6

Table 55 Abdominal, Anatomical Region (not by AIS)

(a) Injuries where there was a reduction of patients in both drivers and front seat passengers
(b) Injuries where there was an increase in patients in drivers, front seat passengers or both

		D_1	D_2	% change	FSP_1	FSP_2	% change
(a)	Kidney	26	13	−50.0	16	11	−31.2
(b)	Contusion — Abdominal wall	50	40	−20.0	19	27	+42.1
	All organs — except kidney	33	39	+18.2	10	15	+50.0

Table 56 Spine and back, Anatomical Region (not by AIS)

(a) Injuries where there was a reduction of patients in both drivers and front seat passengers
(b) Injuries where there was an increase in patients in drivers, front seat passengers or both

		D_1	D_2	% change	FSP_1	FSP_2	% change
(a)	Abrasions, back	25	22	−12.0	17	15	−11.8
	Contusions, back	104	83	−20.0	62	45	−27.4
	Fracture, disloc Cervical	22	19	−13.6	13	10	
(b)	Fracture, lumbar	42	36	−14.3	27	29	+7.4
	Sprain, cervical	736	901	+22.4	320	346	+8.1
	Sprain, lumbar	22	64	+190.9	8	33	+312.5

Table 57 Extremities lower, Anatomical Region (not by AIS)

(a) Injuries where there was a reduction of patients in both drivers and front seat passengers
(b) Injuries where there was an increase in patients in drivers, front seat passengers or both

		D_1	D_2	% change	FSP_1	FSP_2	% change
(a)	Abrasions	364	270	−25.8	226	107	−52.7
	Contusions	459	353	−23.1	283	177	−37.5
	Fracture femur	86	62	−24.9	31	24	−22.6
	Fracture pelvis	36	29	−19.4	9	13	
	Wounds	248	178	−28.2	149	78	−47.7
(b)	Sprain — ankle	25	26	+4.0	14	19	+35.7
	Sprain — knee	19	22	+10.5	10	6	
	Fracture — foot/ankle	35	37	+5.7	18	17	−5.6
	Fracture — leg/knee	97	90	−7.2	28	34	+21.4

Table 58 Extremities, Upper — Anatomical Region (not by AIS)

(a) Injuries where there was a reduction of patients in both drivers and front seat passengers
(b) Injuries where there was an increase in patients in drivers, front seat passengers or both

		D_1	D_2	% change	FSP_1	FSP_2	% change
(a)	Abrasions	227	208	−8.4	146	74	−49.3
	Contusions	349	288	−23.2	183	147	−19.7
	Fractures/disloc Hand, Wrist	24	11	−54.2	14	8	−42.9
	Fractures/disloc Forearm, Elbow	101	54	−46.5	49	27	−44.9
	Fractures/disloc Arm, Shoulder	32	26	−18.8	22	13	−40.9
	Fracture, clavicle	48	43	−10.4	32	18	−43.7
	Fracture, scapula	17	10	−41.2	5	3	
	Sprains	51	40	−21.6	20	19	−5.0
	Wounds	300	209	−30.3	125	78	−37.6
(b)	Nil						

Table 59 Drivers: Change in number of patients between Year 1 and Year 2.

(See text for caveat about significance levels (P values) and interpretation of percentage change).
Total driver casualties: 7659

	Decreases							Increases					
	Y1	Y2	Change	%	P	Prior Hyp		Y1	Y2	Change	%	P	Prior Hyp
Major injuries													
Lungs and pleura	63	42	− 21	−0.27	<0.05	*	Major brain injury	32	46	+ 14	+0.18	NS	
Major forearm fract	26	11	− 15	−0.20	<0.05		Abdomen injury other than kidney	33	39	+ 6	+0.08	NS	
Major thigh fracture	74	61	− 13	−0.17	NS								
Kidney injury	26	13	− 13	−0.17	<0.05								
Major leg fracture	28	19	− 9	−0.12	NS								
Minor injuries													
Wounds, face	1101	617	−484	−6.3	<0.001	*	Sprained neck	736	901	+165	+2.2	<0.001	*
Contusion, face	662	292	−370	−4.9	<0.001	*	Contusion, neck	53	117	+ 64	+0.8	<0.001	
Minor brain injury	606	399	−207	−2.7	<0.001	*	Contusion, scalp	142	180	+ 38	+0.5	<0.05	
Abrasions, face	316	163	−154	−2.0	<0.001	*	Fractured sternum	21	42	+ 21	+0.3	<0.01	*
Contusions, lower extremities	459	353	−106	−1.4	<0.001		Contusion, chest	484	504	+ 20	+0.3	NS	
Abrasion, lower extremities	364	270	− 94	−1.2	<0.001		Facial fracture, minor	130	140	+ 10	+0.1	NS	
Wound, upper extremities	300	209	− 91	−1.2	<0.001								
Contusion, upper extremities	349	268	− 81	−1.1	<0.01								
Wound, scalp	268	192	− 76	−1.0	<0.001								
Wound, lower extremities	248	178	− 70	−0.9	<0.001								

Table 59 (cont'd)

	Decreases						Increases					
	Y1	Y2	Change	%	P	Prior Hyp	Y1	Y2	Change	%	P	Prior Hyp
Fractured ribs	140	86	− 54	−0.7	<0.001							
Eye injuries	98	61	− 36	−0.5	<0.01	*						
Fractured forearm	75	43	− 32	−0.4	<0.01							
Contusion, back	108	83	− 21	−0.3	NS							
Tooth injury	48	27	− 21	−0.3	<0.05							
Abrasion, upper extremities	227	208	− 19	−0.2	NS							
Abrason, chest	40	25	− 15	−0.2	NS							
Contusion, abdomen	50	40	− 10	−0.1	NS							

* Refers to one of the seventeen specified hypotheses (see Section 5.6).

Table 60 Front Seat Passengers: Change in number of patients between Year 1 and Year 2

(See text for caveat about significance (P-values) and interpretation of percentage change).
Total FSP casualties: 3579

	Decreases							Increases					
	Y1	Y2	Change	%	P	Prior hyp		Y1	Y2	Change	%	P	Prior hyp
Major injuries													
Lungs and pleura	24	10	−14	−0.4	<0.05	*	All abdominal injuries other than kidney	10	15	+5	+0.1	NS	
Major brain injury	22	13	−9	−0.25	NS								
Major thigh fracture	30	24	−6	−0.2	NS								
Kidney injury	16	11	−5	−0.1	NS								
Minor injuries													
Wounds, face	553	206	−347	−9.7	<0.001	*	Contusion, chest	194	284	+90	+2.5	<0.001	
Contusions, face	387	121	−266	−7.4	<0.001	*	Sprained neck	320	346	+26	+0.7	NS	*
Minor brain injuries	296	124	−172	−4.8	<0.001	*	Contusion, neck	36	53	+17	+0.5	NS	
Abrasions, lower extremities	226	107	−119	−3.3	<0.001								
Contusions, lower extremities	283	177	−106	−3.0	<0.001								
Abrasions, face	165	65	−100	−2.8	<0.001	*							
Abrasions, upper extremities	146	74	−72	−2.0	<0.001								
Wounds, lower extremities	149	78	−71	−2.0	<0.001								
Wounds, upper extremities	125	78	−47	−1.3	<0.01								
Wounds, scalp	109	68	−41	−1.1	<0.01								

Table 60 (cont'd)

	Decreases						Increases					
	Y1	Y2	Change	%	P	Prior hyp	Y1	Y2	Change	%	P	Prior hyp
Contusions, upper extremities	183	147	−36	−1.0	<0.05							
Minor fracture, face	52	29	−23	−0.6	<0.05	*						
Eye injuries	53	21	−21	−0.6	<0.001	*						
Contusion, scalp	81	60	−21	−0.6	NS							
Minor fracture, forearm	37	16	−21	−0.6	<0.01							
Contusion, back	62	45	−17	−0.5	NS							
Fractured clavicle	32	18	−14	−0.4	<0.05							

* Refers to one of the seventeen specified hypotheses (see Section 5.6).

Table 61 Rear Seat Passengers: Change in number of patients between Year 1 and Year 2

(See text for caveat about significance (P-values) and interpretation of percentage change)
Total RSP casualties: 2298

	Decreases							Increases					
	Y1	Y2	Change	%	P	Prior hyp		Y1	Y2	Change	%	P	Prior hyp
Major injuries													
Nil													
Minor injuries													
Contusions, face	237	155	−82	−3.6	<0.001		Contusions, scalp	59	97	+38	+1.7	<0.05	
Contusions, lower extremities	202	154	−48	−2.1	<0.05		Sprained neck	81	102	+21	+0.9	NS	
Wounds, face	233	208	−32	−1.4	NS		Wounds, upper extremities	45	47	+2	+0.1	NS	
Fractures, upper extremities	77	57	−20	−0.9	NS								
Contusion, back	40	21	−19	−0.8	<0.05								
Abrasions, lower extremities	142	124	−18	−0.8	NS								
Wounds, lower extremities	65	51	−14	−0.6	NS								
Contusion, chest	87	77	−10	−0.4	NS								
Abrasions, face	105	99	−6	−0.3	NS								
Brain injuries, minor	151	145	−6	−0.3	NS								
Facial fractures, minor	36	30	−6	−0.3	NS								

Table 62 Percentage Belted by Location (GB Urban, Mixed, Rural and N. I.) — FSO only

	Y1			Y2		
	Belted	Total	%	Belted	Total	%
GB Urban	274	1135	24.1	745	856	87.0
GB Mixed	582	2453	23.7	1828	1943	94.1
GB Rural	276	894	30.9	740	771	96.0
GB Total	1132	4482	25.3	3313	3570	92.8
N.I.	228	936	24.3	755	848	89.0

Table 63 Non admissions and Admissions (Deaths excluded) — by location

	Non admissions			Admissions			Percentage admitted	
	FSO_1	FSO_2	% change	FSO_1	FSO_2	% change	FSO_1	FSO_2
GB Urban	1149	916	−20.3	296	214	−27.7	20.5	18.9
GB Mixed	2263	1848	−18.3	551	384	−30.3	19.6	17.2
GB Rural	633	611	−3.5	293	220	−24.9	31.6	26.5
GB Total	4045	3375	−16.6	1140	818	−28.2	22.0	19.5
N.I.	758	746	−1.6	179	106	−40.8	19.1	12.4

Table 64 MAIS 1, 2 and 3+ by location

	MAIS 1			MAIS 2			MAIS 3+		
	FSO_1	FSO_2	% change	FSO_1	FSO_2	% change	FSO_1	FSO_2	% change
GB Urban	1096	889	−18.9	284	194	−31.7	70	56	−20.0
GB Mixed	2075	1647	−20.6	574	461	−19.7	187	146	−21.9
GB Rural	627	580	−7.5	236	206	−12.7	69	50	−27.5
GB Total	3798	3116	−18.0	1094	861	−21.3	326	252	−22.7
N.I.	689	668	−3.0	200	150	−25.0	49	35	−28.6

Table 65 National statistics for Great Britain. Dead and seriously injured for front seat occupants and rear seat passengers of cars and light vans. February 1982 — January 1983 and February 1983 — January 1984

	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	$TOTAL_1$	$TOTAL_2$	% change
Dead	2253	1730	−23.2	295	340	+15.3	2548	2070	−18.8
Seriously injured	28577	21534	−24.6	4380	4186	−4.4	32957	25386	−23.0
Total	30830	23264	−24.5	4675	4526	−3.2	35505	27456	−22.7

Figures supplied by Department of Transport, London

Table 66 Road deaths in Great Britain and Northern Ireland

RTA deaths — figures for 1982 and provisional figures for 1983

	Great Britain			Northern Ireland		
	1982	1983	% change	1982	1983	% change
Drivers & Passengers	2443	2009	−18.0	118	66	−44.0
of Motor Vehicles	43%	39%		55%	38%	
Pedestrians	1869	1891	+1.2	67	72	+7.5
	33%	36%		31%	42%	
Motor Cyclists	1090	959	−12.0	21	21	0.0
	19%	19%		9.7%	12%	
Pedal Cyclists	294	318	+8.2	9	14	+55.0
	5%	6%		4.2%	8.1%	
Others	0	0		1	0	
Total	5696	5177	−9.0	216	173	−20.0

Figures supplied by the Department of Transport, London, Statistical Branch and Royal Ulster Constabulary, Traffic Branch.

Table 67 Non–fatal casualties from Road Traffic Accidents, Northern Ireland 1982 and 1983

	1982	1983	% change
Car drivers	2733	2442	−10.6
Car passengers	2540	2360	−7.1
All other road users	2709	2739	+1.1

Figures supplied by the Department of the Environment, for Northern Ireland, Road Safety Branch.

Table 68 Distribution of belted and unbelted fatal casualties by seating position in first and second year

	Year 1					Year 2				
	D_1	FSP_1	FSO_1	RSP_1	T_1	D_2	FSP_2	FSO_2	RSP_2	T_2
Belted	7	3	10	2	12	24	13	37	0	37
Unbelted	36	17	53	11	64	10	4	14	14	28
Total belted and unbelted	43	20	63	13	76	34	17	51	14	65
Not known	18	7	25	0	25	6	4	10	0	10
Grand total	61	27	88	13	101	40	21	61	14	75

Table 69 Distribution of belted and unbelted car occupants in cars where there was a fatality by seating position in first and second year

	Year 1					Year 2				
	D_1	FSP_1	FSO_1	RSP_1	T_1	D_2	FSP_2	FSO_2	RSP_2	T_2
Belted	11	6	17	2	19	39	28	67	0	67
Unbelted	51	33	84	40	124	11	7	18	39	57
Total belted and unbelted	62	39	101	42	143	50	35	85	39	124
Not known	24	14	38	5	43	10	5	15	0	15
Grand total	86	53	139	47	186	60	40	100	39	139

Table 70 Ratios Driver : Front seat passenger : Rear seat passenger in community among patients and among coroners' casualties in first and second year

	D	FSP	RSP
Motorists in community	1	0.50	0.35
Patients in Year 1	1	0.53	0.43
Coroners' casualties Year 1	1	0.44	0.21
Patients in Year 2	1	0.43	0.34
Coroners' casualties Year 2	1	0.53	0.35

(Figures for motorists in community taken from Nation Traffic Survey, 1978/79).

Table 71 Percentage belted front seat occupants in community, among patients, among all occupants of cars with fatalities, and among fatal casualties

	FSO_1	FSO_2
In community GB	41	95
Among patients	25	93
Occupants in cars with fatalities	17	79
Fatal casualties (coroners' series)	16	73

(Figures for motorists in community taken from Department of Transport Statistics, 1982 and 1983).

Table 72 Distribution of coroners' casualties by Injury Severity Score (ISS) and by seating position

	D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
1–24	18	11	−39	3	5		21	16	−24	5	2		26	18	−31
>25	43	29	−33	24	16	−33	67	45	−33	8	12		75	57	−24

Table 73 Distribution of coroners' casualties by seating position and Maximum Abbreviated Injury Scale (MAIS)

	D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
1–3	13	7		5	5		18	12	−33	4	2		22	14	−36
4	16	11		6	2		22	13	−41	2	2		24	15	−38
5	24	15		12	7		36	22	−39	6	6		42	28	−33
6	8	7		4	7		12	14	+17	1	4		13	18	+46

Table 74 Number of injuries by degree of severity, Abbreviated Injury Scale (AIS)

	D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
AIS1	374	248	−33.7	150	132	−12.0	524	380	−27.5	73	69	−5.5	597	449	−24.2
AIS2	193	108	−44.0	53	71	+34.0	246	179	−27.2	28	41	+46.4	274	220	−19.7
AIS3	145	106	−26.9	84	69	−17.9	229	175	−23.6	35	46	+31.4	264	221	−16.3
AIS4	70	42	−40.0	32	27	−15.6	102	69	−32.4	4	10		106	79	−25.5
AIS5	46	32	−30.4	17	19	+11.8	63	51	−19.0	9	16		72	67	−6.9
AIS6	8	7		4	9		12	16	+33.0	1	4		13	20	+54.0

Table 75 Distribution of coroners' casualties with 0–4 serious injuries, 5–9 serious injuries and over 10 serious injuries.

	D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
0–4	36	26	−28	12	10		48	36	−23	8	8		56	44	−20
5–9	20	10	−50	13	7		33	17	−48	4	3		37	20	−46
10+	5	4		2	4		7	8		1	3		8	11	
Total	61	40		27	21		88	61		13	14		101	75	

Table 76 Distribution of injuries by body region

	D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
Head and neck	140	97	−31.7	64	43	−32.8	204	140	−31.4	32	34	+6.3	236	174	−26.7
Thorax	177	100	−43.5	85	77	−9.4	262	177	−32.4	28	38	+36.0	290	215	−25.9
Abdomen	67	36	−46.0	22	21	−4.5	89	57	−36.0	10	22	+120.0	99	79	−20.0
Spine	11	24	+118.0	4	10		15	34	+127.0	0	4		15	38	+153.0
Lower extrem.	54	37	−32.0	14	24	+71.0	68	61	−10.0	9	10		77	71	−8.0
Upper extrem.	39	27	−31.0	8	20	+150.0	47	47	0.0	5	7		52	54	+4.0
External	348	228	−34.5	143	147	−11.2	491	356	−27.5	71	73	+2.8	562	429	−23.7

Table 77 Distribution of injuries by body region in present study compared with studies by Gissane and Hossack

	Percentage distribution of injuries				Injuries per 100 fatal casualties			
	Gissane 1963	Hossack 1972	Present Study Year 1	Present Study Year 2	Gissane 1963	Hossack 1972	Present Study Year 1	Present Study Year 2
Head & Neck	34.4	34.9	30.7	28.0	142	97	233	232
Thorax	34.3	36.1	37.7	33.4	142	100	287	279
Abdomen	16.1	12.0	12.9	12.6	38	33	97	105
Spine	3.7	3.0	2.0	6.1	9	8	15	51
Extremities	11.3	14.0	15.8	19.9	27	10	66	167

Table 78 Distribution of injuries in Head and Neck Regions

	D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
Intracranial injuries	48	47	−2.1	38	21	−44.7	86	68	−20.9	15	16	+6.7	101	84	−16.8
Skull fractures	42	18	−57.0	15	12	−20.0	57	30	−47.0	8	12		65	42	−35.4
Face fractures	30	20	−33.0	8	3		38	23	−39.0	7	5		45	28	−37.8
Other injuries	19	10	−47.0	3	4		22	14	−36.0	2	1		24	15	−37.5
Total Head Injuries	139	95	−31.4	64	40	−37.5	203	135	−33.5	32	34	+6.3	235	169	−28.1
Neck injuries	1	2		0	3		1	5		0	0		1	5	
Total head and neck injuries	140	97	−31.7	64	43	−32.8	204	140	−31.4	32	34	+6.3	236	174	−26.7

Table 79 Distribution of chest injuries

	D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
Lungs and pleura	58	35	−40.0	34	30	−12.0	92	65	−29.0	12	17		104	82	−21.0
Heart	17	9		4	5		21	14	−33.0	5	2		26	16	−38.0
Aorta	12	7		8	8		20	15	−25.0	2	3		22	18	−18.0
Fractured ribs	70	42	−40.0	31	28	−10.0	101	70	−37.0	8	14		109	84	−22.9
Fractured sternum	12	1		4	3		16	4		0	0		16	4	−76.0
Other	8	6		4	3		12	9		1	2		13	11	
Total	177	100	−43.5	85	77	−9.4	262	177	−32.4	28	38	+36.0	290	215	−25.9

Table 80 Distribution of abdominal injuries

	D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
Gastrointestinal tract	4	3		1	1		5	4		1	3		6	7	
Liver	27	10	−63.0	6	4		33	14	−58.0	3	8		36	22	−39.0
Spleen	14	9		9	6		23	15	−35.0	2	2		25	17	−32.0
Kidney	9	7		1	5		10	12		3	6		13	18	+38.0
Other	13	7		5	5		18	12	−33.0	1	3		19	15	−21.0
Total	67	36	−46.0	22	21	−4.5	89	57	−36.0	10	22	+120.0	99	79	−20.2

Table 81 Distribution of spinal injuries

	D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
No cord lesion															
Fract/disloc cervical	2	5		2	2		4	7		0	1		4	8	
Thoracic	5	8		1	1		6	9		0	1		6	10	
Lumbar	0	0		0	0		0	0		0	1		0	1	
Sacral	0	1		0	0		0	1		0	0		0	1	
Total fract/disloc with no cord lesion	7	14		3	3		10	17		0	3		10	20	
With cord lesion															
Fract/disloc cervical	4	7		1	4		5	11		0	1		5	12	
Thoracic	0	3		0	2		0	5		0	0		0	5	
Lumbar	0	0		0	1		0	1		0	0		0	1	
Total fract/disloc with cord lesion	4	10		1	7		5	17		0	1		5	18	
Total spinal lesions	11	24	+118	4	10		15	34	+127	0	4		15	38	+153

Table 82 Distribution of injuries in lower extremities

	D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
Fract/disloc feet/ankle	4	4		1	1		5	5		0	0		5	5	
Fract/disloc leg/knee	25	11	−56.0	7	11		32	22	−31.0	4	3		36	25	−31.0
Fract/disloc thigh/hip	14	16	+14.0	4	9		18	25	+39.0	3	4		21	29	+38.0
Fracture pelvis	11	4		0	2		11	6		2	3		13	9	
Other injuries	0	2		2	1		2	3		0	0		2	3	
Total lower extremities	54	37	−31.5	14	24	+71.0	68	61	−10.3	9	10		77	71	−7.8

Table 83 Distribution of injuries in upper extremities

	D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
Fract/disloc hand/finger	2	3		0	3		2	6		1	0		3	6	
Fract/disloc Forearm/elbow	20	15	−25.0	5	7		25	22	−12.0	2	3		27	25	−7.4
Fract/disloc Arm/shoulder	11	7		2	4		13	11		1	1		14	12	−14.3
Fract/disloc Clavicle	5	2		1	4		6	6		1	3		7	9	
Other injuries	1	0		0	2		1	2		0	0		1	2	
Total upper extremities	39	27	−30.8	8	20		47	47	0.0	5	7		52	54	+3.8

Table 84 Distribution of external injuries

	D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
Burns	0	2		2	1		2	3		0	2		2	5	
Abrasions	126	120	−4.8	47	58	+23.4	173	178	+2.9	28	23	−17.9	201	2101	0.0
Contusions	80	47	−40.0	40	27	−32.5	120	75	−37.5	27	30	+11.1	147	105	−28.6
Wounds	142	58	−59.2	54	42	−22.2	196	100	−49.0	16	18	+12.5	212	118	−44.3
Total external	348	228	−34.5	143	127	−11.2	491	356	−27.5	71	73	+2.8	562	429	−23.7

Table 85 Distribution by time of death after accident

	D_1	D_2	% change	FSP_1	FSP_2	% change	FSO_1	FSO_2	% change	RSP_1	RSP_2	% change	T_1	T_2	% change
Before reaching hospital	39	29	−26.0	16	16		55	45	−18.0	11	9		66	54	−18.0
First day in hospital	6	2		2	1		8	3		1	2		9	5	
2 — 7 days in hospital	4	6		8	1		12	7		1	1		13	8	
after 7 days in hospital	12	3		1	3		13	6		0	2		13	8	
Total after admissions	22	11	−50.0	11	5		33	16	−52.0	13	14		35	21	−40.0

Table 86 Distribution of coroners' casualties by medical disease contributing to death

	Year 1	Year 2
Fresh myocardial infarction	3	1
Old myocardial infarction	1	0
Acute pericarditis	1	0
Cardio vascular accident	1	0
Chronic bronchitis	1	0
Alcoholic intoxication	1	0
Drowning	0	1
Total medical conditions	8	2
No contributary medical conditions	93	73
Total	101	75

Table 87 Distribution of coroners' casualties by presence of complications and malfunctions before death

	Year 1	Year 2
Haemorrhogic shock	6	2
Pulmonary embolus	3	3
Shock lung	3	2
Bronchiopneumonia	3	1
Respiratory distress	3	0
Cardiac arrest	1	1
Asphyxiation	1	1
Fat embolism	0	1
Disseminated candidiasis	1	0
Total casualties with complications	21	11
Total casualties — no complications	80	64
Total	101	75

Table 88 Distribution of injuries causing death by region

	Year 1		Year 2	
	Number of casualties	%	Number of casualties	%
Head injuries	38	(41.0)	24	(33.0)
Neck injuries	0		1	(1.4)
Thoracic injuries	39	(42.0)	26	(36.0)
Abdominal injuries	12	(13.0)	6	(8.3)
Spinal injuries	3	(3.2)	11	(15.0)
External injuries	1	(1.1)	4	(5.6)
Total	93		72	

Table 89 Distribution of injuries considered to have contributed most to death in each body region.

	Year 1	Year 2
Head injuries		
Intracranial haemorrhage	12	12
Wound of the brain	15	6
Contusion of the brain	7	5
Total brain injuries	34	23
Fracture maxilla	2	1
Fracture skull	2	0
Total head injuries	38	24
Neck injuries		
Rupture of larynx	0	1
Thoracic injuries		
Rupture/wound aorta	18	14
Rupture/wound heart	9	4
Contusion heart	1	2
Injury coronary vessels	1	0
Total heart injuries	11	6
Haemorrhage lungs/pleura	2	1
Wound lung	1	1
Contusion lung	1	2
Total lung/pleura injuries	4	4
Fractured ribs	3	1
Fractured sternum	2	0
Wound oesophagus	1	0
Wound chest wall	0	1
Total thorax injuries	39	26
Abdominal injuries		
Rupture/wound liver	9	3
Rupture/wound spleen	2	2
Contusion spleen	1	1
Total abdominal injuries	12	6
Spinal injuries		
Fract/disloc cervical spine	3	9
Sprain cervical spine		1
Fracture lumbar spine		1
Total spinal injuries	3	11
External injuries		
Burns	1	4

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